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A NEW DEPARTURE IN LOCOMOTIVE CONSTRUCTION.

By Dr. Alfred Gradenwitz.

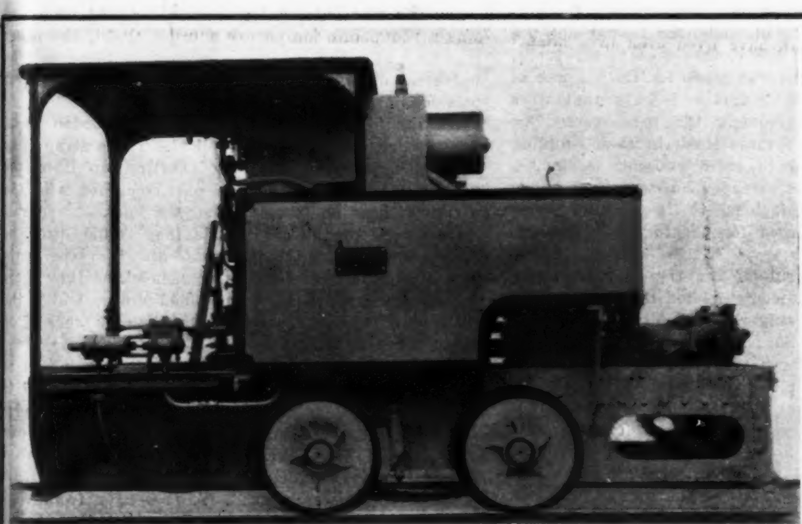
While long-distance transportation has made enormous strides since the construction of the first steam railway, industrial transport over short distances is still at a relatively primitive stage. It is true that the introduction of industrial motor cars has done much toward improving this state of affairs, but they have their limitations, and fail to solve the problem.

It would obviously be a decided mistake to design a transportation service of this kind exactly on the model of a long-distance railway; and while coal locomotives still are the very soul of long-distance conveyance, they are generally quite unsuitable for the purposes of industrial railways. Even if the amount of raw material worked each day be considerable, it is of advantage to convey it in small individual trains.

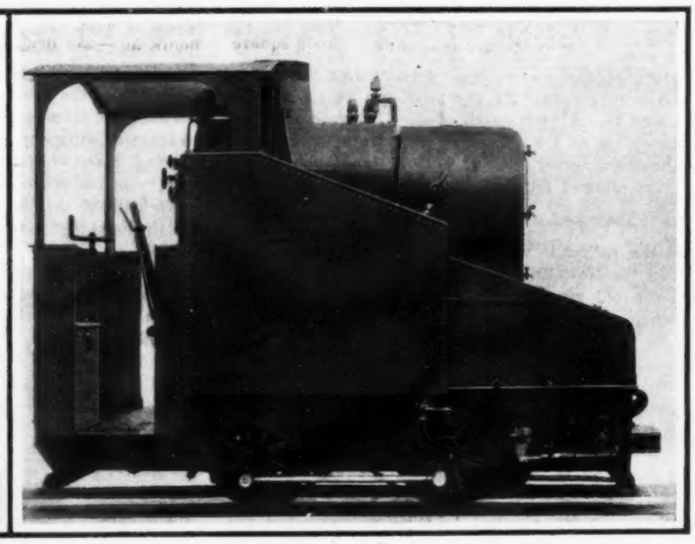
A novel type of steam locomotive for drawing such trains has been recently constructed by Arthur Koppel. Liquid fuel is used, but in contrast with gasoline or alcohol locomotives, it is readily reversed without the use of any intermediary gearing, and both the power and speed are controlled by altering the steam charge in the cylinders, without resorting to the expedient of different ratios of transmission. The power and speed are thus readily adapted to the gradient to be negotiated and the load to be conveyed.

While the "hydroleum" locomotive, as it is called,

THE OIL LOCOMOTIVE OF A BELGIAN MINE.



HYDROLEUM LOCOMOTIVE WITH DRIVE GEAR DISENGAGED.



HYDROLEUM LOCOMOTIVE 23.62 INCHES GAGE, 5½ TONS WORKING WEIGHT, 25–30 HORSE-POWER.

HYDROLEUM LOCOMOTIVE HAULING A LOADED TRAIN.

A NOVEL GERMAN OIL LOCOMOTIVE.

possesses all the advantages of steam engines, having a high starting power and overload capacity, it, on the other hand, does away with the disadvantages; as it utilizes more fully the heating value of the fuel, there being no ashes or slag. The absence of any smoke or smell is another valuable feature of this novel locomotive. There are no ashes and slag to deal with, and the locomotive throws no sparks. Whereas it takes one and one-half to two hours to raise the steam in an ordinary locomotive, the hydroleum locomotive can be got into working order in about fifteen or twenty minutes.

These valuable properties are mainly due to the design of the boiler and the choice of the fuel, which is either crude oil or tar oil. The latter, as is well known, is a residue from the manufacture of gas and coke, and can be obtained at a very low price; while being as fluid as water, tar oil, as compared with lighter petroleum products, is neither explosive nor combustible, combustion being produced only after a proper mixture with air. The hydroleum locomotive is provided with a water-tube boiler, and possesses a considerable heating surface and remarkable capacity with very low dimensions.

Two different types of engine are generally used; either a twin engine analogous to the ordinary engine of coal locomotives, or a four-cylinder steam engine. The drive gear of this four-cylinder engine, which is the one most commonly used, is entirely inclosed and runs permanently in oil. The use of four parallel cylinders with cranks set at convenient angles secures a satisfactory compensation of the oscillating masses. Whenever it is desired to prevent the escape of steam, e. g., in tunnels, a condenser intended for temporary use can be fitted into the water boxes.

RAILROADING IN ITS INFANCY.

STAGE DRIVERS MADE CONDUCTORS OF PASSENGER TRAINS.

BY GEORGE P. FLOYD.

When we think of the conditions and methods of traveling in this country seventy-five years ago and compare them with those of the present date, no one, unless he has had actual experience and has personally witnessed the steady progress made during the past sixty-five years, can begin to realize the changes and improvements in the modes of travel during that space of time. Those old stage coaches that we used to ride in before the railroads came into play, hung on leather thorough-braces, were mighty easy riding.

The first notice of coaches being hung on straps is that in which Louis XIV made his public entrance into Paris about the middle of the seventeenth century. Coaches hung on straps seem to have been introduced into England by Fritz Allen, Earl of Arundel, in 1555. The first mail coach in the United States was set up at Bristol, New Jersey, by John Palmer in 1732. It ran between New York and Boston, but not regularly. In 1756 there was a coach running between New York and Philadelphia—ninety miles; the time required to cover the distance was three days. In 1765 another coach was put on the line and it ran three days in each week. In 1788 the line was increased to two coaches daily each way, leaving Philadelphia at 10 A. M. In 1811 there were four coaches daily, each way, leaving Philadelphia at 10 A. M., stopping at Brunswick, New Jersey, over night, and arriving in Jersey City the next day at 12 M. The fare was $8. A mail coach of the Diligence Line left Philadelphia at 1 P. M. every day, traveled all night, coming into Jersey City at 6 A. M., and each passenger was allowed fourteen pounds of baggage.

FROM STAGE COACH DRIVER TO CONDUCTOR.

As the railroads were completed and put in operation in the New England States about sixty-five years ago, the old stage drivers were made conductors of passenger trains. A number of the passenger conductors on the Boston and Providence and the Old Colony were stage drivers before the roads were completed.

Until 1852 there was no railroad running west of Chicago, all traveling being done in coaches. At that time I was running a passenger train on the Michigan Central road from Chicago to Detroit. I have seen as many as thirty-five or forty twelve-passenger stage coaches in front of the stage office at Lake and State streets, all loading up with passengers and baggage for all parts of the West. It is a well-known fact that the first railroad in America was a tramway, built in 1826 from the Quincy, Mass., granite quarries to a wharf on the Neponset River. It was used to transport blocks of granite to build the Bunker Hill monument; the road was three miles in length. About one hundred feet of that road is still in existence, left as a relic. The rails used to construct the road were scantlings laid on granite ties, with strap iron nailed on top. The cars were hauled by oxen and horses.

On the morning of August 9th, 1831, at the head of Lydius Street, Albany, N. Y., there stood on a railroad track a queer looking engine; behind it was a little tender with two barrels of water and about a half cord of pitch-pine wood and two strange looking passenger cars, consisting of the bodies of two stage coaches fastened upon railroad trucks. The little locomotive was built at the West Point foundry, and was taken to Albany by river boats. It weighed but four tons. It, with the two cars, was about to make a trial trip from Albany to Schenectady. A great crowd had assembled, and it was nearly time to start the train. Accordingly, everybody was full of interest and curiosity. The locomotive was the first of that character ever built to run on a passenger train in this country. It was called the "De Witt Clinton." The road was called the Mohawk and Hudson. The engineer was E. Mathews; and the conductor, John T. Clark, the first conductor in the United States to run a passenger train, was an old stage driver. He stepped from platform to platform outside the coaches to collect the tickets, previously sold at the hotels and other places in the city. Mounting a little buggy set on the front end of the first car he blew his tin horn as the signal for departure. The engine started with a great jerk, much puffing and wheezing, and loud shouts from the crowd. The train moved off amid the black smoke from the pitch-pine wood, and a shower of sparks as large as walnuts, and thundered along toward Schenectady. The trucks of the cars were coupled together with chains or chain links, leaving from two to three feet slack, and when the locomotive started it took up the slack by jerks with such force as to jerk the passengers and send them flying across the coaches from under their hats, and when the train slacked up the dose was repeated. The pitch-pine smoke and cinders came pouring back the whole length of the train. Each of the outside passengers who had an umbrella raised it as a protection against smoke and fire. They found it but a momentary protection, for in the first mile the last one went overboard, all having their covers burnt off from the frames. A general melee took place among the passengers, each whipping his neighbor to put out the fire that was burning the clothes from their backs. A successful experiment was made for the purpose of remedying the terrible bumps and jerks that were causing such a panic among the passengers. The train was stopped, the three links in each coupling having been stretched to their extreme tension, a rail from the fence was extended horizontally between each pair of cars and fastened to its place by means of the packing yarn used for packing the cylinders. It was a success.

Some of the incidents of the trip were striking. A general notice of the contemplated trip having been given, it excited not only the curiosity of those living along the line of the road, but of persons from a distance, causing a large collection of people at all the interceding roads along the route. Everybody, together with his wife and children, came in all kinds of conveyances, and being as ignorant of what was coming as were their horses, drove up to the railroad as near as they could get, only looking for the best position to secure a good view of the train as it passed. As it approached, the horses took fright and wheeled, upsetting buggies, carriages, carts and hay wagons, and leaving for parts unknown. The train arrived in Schenectady with the passengers in a dilapidated condition as to clothes and hats, half of them being burned from their backs. After partaking of refreshments the train party returned to Albany. Such was the first locomotive trip in New York.

It should be added that the Mohawk and Hudson Railroad now forms the eastern terminal portion of the New York Central road at Albany. Originally eleven different companies owned and operated the railroads now composing the line connecting Albany and Buffalo. In 1850 there were seven distinct companies between these cities. The following year they were united under one management.

The Erie Railroad joined New York and Dunkirk on Lake Erie in 1851. The Baltimore and Ohio road reached the Ohio River the same year. By 1854 it became possible to travel from the Atlantic seaboard to Chicago by rail. In 1855 the Chicago and Rock Island connected Chicago with the Mississippi River. In 1837 there were but twenty miles of railroad in this country, while in 1840 there were 2,818 miles in operation; in 1850, 19,021 miles; 1860, 30,914 miles; 1870, 52,914 miles; 1880, 93,296 miles; 1890, 163,797 miles; 1900, 195,346 miles. Until 1850 three-fourths of the mileage was in the New England States.

The people in the United States have built more miles of railroad than were built by the three leading countries of Europe.

The first passenger train in the State of Pennsylvania made its trial trip in March, 1832, from Philadelphia to Germantown, drawn by the locomotive "Ironsides," built by M. W. Baldwin, founder of the great locomotive works that now bears his name. The engine weighed seven tons. On the first trial of the "Ironsides" it was discovered that the drivers were too light to give adhesion to the rail. So the builder and two machinists pushed it ahead until speed enough had been obtained, when all jumped aboard the engine in order that their weight might keep the wheels down. Moreover, the boiler was too small for the engine and steam could not be generated fast enough to keep it in motion for any length of time, so that for a portion of the distance from Philadelphia to Germantown it was necessary alternately to push and ride in order to cover the distance.

One of the most curious of early cars was the "Victory," a model of which is preserved in the office of the Eastern Railroad Association in New York. It was the first Monitor, or raised roof car, and was run on the Philadelphia & Reading road in 1836. The seats were arranged like an omnibus around the sides—the car was entered from the sides. At each end was a room, one for use as a toilet closet, the other was used as a bar, for our ancestors, in those days of universal drinking, were unable to do without their potations even on a railroad trip.

All the first railroads made use of wooden rails, upon which strap iron was spiked. These strap rails had an unpleasant fashion of curling up from the weight of a car on the central part combined with the action of heat and frost; when the ends of the rail were struck by the car wheels they would often be forced up through the bottom of the car; the train would have to stop and the snakehead, as they were called, would have to be pounded down, while the train went over it. Passengers on the cars were often injured by the accidents.

The old-fashioned custom of booking passengers as they did in old stage coach times was transferred to the railroads; each passenger's name was taken and a slip given him with the number of his seat in the car. This custom continued for a number of years after the first roads were run. It was not until 1853 that coupon tickets were issued. A passenger from New York to Chicago was obliged to buy a ticket over each road; that is, from New York to Albany over the Hudson River road, from Albany to Buffalo over the New York Central, from Buffalo to Detroit over the Great Western Road of Canada, and from Detroit to Chicago over the Michigan Central road.

In 1854 the fare from New York to Chicago was $26. The local tickets were pasteboard cards with no date and used over and over until they were worn out. We did not know what a ticket punch was until 1856. No check was used on the conductors in any way. The fare was the same if paid on the train as it was when a ticket was purchased. The main object of the passengers was to get a good seat on the train, ticket or no ticket. While I was running a passenger train on the Michigan Central road in 1854-55, my cash way bill was frequently $1,500 and $1,800 a trip, on the day run. No tickets were sold at any of the stations on the road after 12 o'clock at night, all fares being paid on the train after that time, yet the boys gave the road a square deal. Some of the boys made money selling eggs, butter, and huckleberries, and made enough on the same to buy a brown-stone front or a farm and retire from the road.

PERILOUS DAYS IN TEXAS.

In 1873 there was but one railroad completed and running in Texas, the Houston & Texas Central, running from Houston to Denison, though a number of other roads were being constructed. The travel in that State was mostly done in stage coaches. Ben

Ficklin & Co. were the largest mail contractors and owners of stage coaches in that State. At one time they were running nearly 500 coaches. During 1875-77 the writer was acting as manager of the Ben Ficklin line of coaches from San Antonio to El Paso, San Antonio to Austin, Dallas to Fort Worth, Forth Worth to Fort Concho, and Fort Worth to Wetherford, about 1,200 miles. At that time Texas was a wild State, full of renegades, bandits, and outcasts from the northern States. Those were perilous days in that State; it was "dangerous to be safe." Often the Mexican greasers would come over and run off our horses and stock.

The knights of the road frequently held up our coaches and they did not hesitate to kill as well as rob. The officers of the law were very slack in performing their duty; in fact, we didn't know whom to trust. The vigilance law was often put in force. The stringing up of one or two of the desperate devils who were robbing and killing people would cool the desperadoes off for a while. As our coaches carried valuable money packages, we frequently were obliged to send an armed guard with the coaches.—The Railway Conductor.

WADAGAKI'S INCLOSED TURBINE PROPELLERS.

HIGH-SPEED TURBINES AND SLOW-SPEED VESSELS.

SINCE the introduction of the marine turbine there has been no lack of inventors engaged upon the problem of reconciling the high normal speed of turbine machinery with the requirements of moderate-speed vessels. Effecting a compromise by speeding the turbines down and the propellers up, is as unsatisfactory as most compromises, for neither end is working at its best. There are two conditions to be provided for—namely, the requirements of naval vessels which must be capable of attaining high speeds as well as cruising economically at low speeds, and those of cargo steamers, whose speed is always low. The first condition would be best fulfilled by a variable-speed ratio between the turbines and the propellers, while for the second a simple reduction to the propeller-shaft would suffice. For variable speed to be obtained economically electrical transmission has often been suggested, but the space required, the weight and the cost combined, appear to render the idea impracticable. The same plant might be installed where merely a speed reduction was required, but the same considerations, of course, apply. There are, however, modifications of the plan which might be feasible, such as using an exhaust-steam turbine with an electric drive, and letting reciprocating engines drive the other propellers direct.

Several other ideas for increasing the economy of turbine vessels are mentioned in a paper read by Mr. Yasuzo Wadagaki before the North-East Coast Institution of Engineers and Shipbuilders. Reduction of propeller speed by means of gearing he considered out of the question, in view of the large amounts of power to be transmitted; but it will be remembered that Mr. Stoney, in his recent lectures before the Society of Arts, appeared to think the idea not so impracticable as many people imagined, because of the great advances made in gearing construction. Mr. Wadagaki made one curious suggestion—namely, to use the exhaust steam from the main engines in a turbine which should drive a turbo-compressor taking steam from the boilers and delivering it to the main engines in a compressed and superheated condition. The originator of the plan can hardly have tried to design the plant for carrying it out, or have looked into the arithmetic of the question.

Mr. Wadagaki's own idea, which he puts forward as the result of many years' study of the problem, is to run the turbines at their natural high speed and arrange the propeller to suit. He proposes to put the propeller in a tube flared at both ends, so that the cross-sectional area gradually contracts to a minimum at the point where the propeller is situated. The water at this point would thus be moving at a high velocity, and the propeller might therefore be run at a corresponding speed without incurring excessive slip. The plan has been suggested many times before, but it has never come to anything. There is no doubt that the velocity of the water would be increased at the throat of the tube without much loss, but the greater speed is only obtained by the reduction of the hydrostatic head. The action is, in fact, exactly what goes on in a Venturi meter or a Ferranti valve. Now, to propel a ship at a given speed obviously requires a certain thrust, whether the propeller runs fast or slow. The thrust has, in a sense, nothing to do with the propeller or its arrangement, and may be looked on as an outside force acting on the ship. But it has to be transmitted through the propeller, and the limiting thrust which a propeller will give is determined by cavitation phenomena, which arise when the pressure per square foot on the blades exceeds a certain amount. The less the hydrostatic head the sooner, of course, will cavitation occur, as has been verified experimentally by the Hon. C. A. Parsons. If there is no hydrostatic head at all, then any relative motion of the propeller will cause cavitation. Hence any reduction of the hydrostatic head, such as is involved in the artificial increase of the velocity of the water flowing past the propeller, tends to introduce cavitation troubles. The whole proposition is, in fact, as broad as it is long, and the idea of any particular gain by inclosing the propeller in a contracted tube is fallacious.

Mr. Wadagaki's paper contains an account of experiments carried out some time ago at the Imperial Dockyard at Sasebo, with the object of ascertaining the effect of inclosing the propeller as described. The trials were made in a tank with the propeller-shaft about 30 inches below the surface of the water. The propeller was driven by an electric motor and caused the water to circulate around the tank. The thrust obtained at various powers and speeds was measured by a spring device. The propeller used was 8 inches in diameter, with three blades, having a uniform pitch of 10¼ inches. In one series of trials it was inclosed in a tube 20 inches long, having an inlet diameter of 13½ inches and an outlet of 11½ inches. The contracted part, which was 5 inches behind the inlet, was 9 inches in diameter, thus leaving ½ inch clearance around the propeller blades. The outside of the tube was cased in to form a straight taper from one end to the other.

The results of trials, both with and without the casing, are given by the author, and the only conclusion which it appears legitimate to deduce from them is that for equal speeds of revolution the uncased propeller gives greater thrust and absorbs more power than the other. This holds at all speeds from 700 to 1,300 revolutions, and is very definite. For equal powers, the cased propeller gives the higher thrust; but to do this it has to run at slower speeds than when there is no casing round it. The author appears to wish to emphasize the increased thrust per horse-power obtained with the tube, but a tube is worse than useless for turbine vessels if it involves lowering the propeller speed. The whole object of the idea is to enable the screw to run faster without cavitation, and Mr. Wadagaki's experiments do nothing to show that this end can be attained. If the increased velocity at the neck of the tube could be obtained without reduction of the hydrostatic head, there would be something to be said for the idea, but even then the energy would have to come from somewhere, and to be paid for in some way or other. As we have already said, the idea is founded on a fallacy, though it is a very persistent one.—Engineering.

ANTI-FRICTION ALLOYS FOR BEARINGS.*

THE load at which rubbing begins is generally greater, the harder the metals in contact; the coefficient of friction on the other hand is generally smaller, the harder the metal. In order to reduce friction as well as to avoid cutting, hard substances should be used for bearing surfaces—hence the use of phosphor bronze.

The use of hard substances, however, corrects only the effects of defective lubrication, and assumes that the surfaces in contact are regular, so that the load is uniformly distributed and not concentrated in certain points. If the metal is hard and unyielding, the pressure on these points becomes considerable and leads to heating and cutting. Hence the bearing metal must have a certain plasticity so as to mold itself around the shaft and increase the surface of contact. But the bearing itself is constantly wearing away irregularly, and the plasticity of the metal must be such as to constantly restore its contact with the shaft.

We are led, therefore, to seek in alloys for bearings subjected to friction, two apparently contradictory characteristics, namely, hardness and plasticity. We may combine them, however, in using metals composed of hard grains imbedded in a plastic matrix, and this is the main principle aimed at in anti-friction alloys.

The constitution of bronzes is the reverse of that of white alloys. Instead of hard grains in a plastic eutectic, we have soft grains in a hard eutectic for the same degree of plasticity. The behavior of bronze and white metals is not identical, and the bronze has a greater tendency to cut than the white alloys.

If the weight borne by the bearing of a uniformly-rotating shaft be gradually increased, when a certain load is reached the oil is driven from the space between the shaft and the bearing, and the metal becomes heated. In the case of white metal the wear is then considerable, and if the load continues to increase, the alloy may be partially fused. In the case of bronzes, the portions rich in copper adhere to the shaft, forming a rough surface and increasing the friction.

Bronzes are then inferior to white metals because they are less plastic and do not mold themselves as well around the axle; their greater strength does not permit a heavier load, for then the lubrication is interfered with, and they tend to become heated. Bronzes, on account of their constitution, have a greater tendency to cut than white alloys, and thus produce a deterioration of the axle.

An anti-friction alloy should have hard grains in a plastic matrix; then the load is carried by the hard grains which have a low coefficient of friction, and the cutting can only take place with difficulty. The plasticity of the cement makes it possible for the bearing to adjust itself around the shaft, thus avoiding local pressures, which are the chief cause of accidents. Such properties may be obtained in binary alloys with such metals as antimony, tin, and copper, which form chemical compounds. The requisite properties are better obtained in ternary alloys, which give a good plastic matrix (eutectic). To test an anti-friction alloy, compression and the microscope are invaluable aids.

* Extract from a paper by Mr. A. H. Hiorns, read before the Birmingham Association of Mechanical Engineers.

DEEP-SEA RESURRECTIONS.

WHEN a ship disappears beneath the waters it is by no means certain that it will never be seen again. It may rise after a few days, or even a few hours, and continue afloat for months, a constant menace to navigation. This, of course, applies only to wooden ships. When an iron ship goes down it stays down.

Some years ago a coal-laden schooner collided with an unknown vessel in a thick fog at night a hundred miles from Cape Hatteras. The unknown continued on her way, and was swallowed up in the fog, but the schooner, with a great hole torn in her bows, began to settle, and her crew was launching the boats when seen and rescued by a passing southern liner. The abandoned ship was then two-thirds full of water and bows under. In less than ten minutes after the crew had been taken off, the schooner's stern rose in the air, and she made her final plunge. As she went down the deck blew up, with a noise like thunder. Two months later she was sighted floating bottom up below Cape Hatteras, drifting south in the trend of the Gulf Stream. The explanation of her resurrection was a simple one. Her cargo had shifted forward when the bow tilted down with the inrush of the water and the rolling of a rough sea. As she went down, the coal ran out through the great hole there before she reached the bottom, and, relieved of its weight, she rose again, turning turtle as she did so. A ship with a broken back is also likely to rise as soon as her cargo floats out or disintegrates under the action of the salt water.

A wreck in ballast or with a light cargo drifts with bows from the waves if there is no current worth mentioning, but in a strong, swift current the bow will face in the opposite direction to that in which the current is moving.

A ship bottom-up will float with about an eighth of the depth of her hull out of water, and in a heavy sea will lie lengthwise of the waves. When a ship has been down long enough to become thoroughly waterlogged and riddled by worms, it never rises again from its ocean grave.—English Mechanic and World of Science.

One mine in Australia is being operated for rutile. It is owned and worked by Francis J. Spence, and is 45 miles northeast of Adelaide in South Australia. The present production is small, but could be increased at any time, if a demand should arise for the mineral, as for instance, from the use of titanium in making steel. At present the demand is not important. Rutile is valuable chiefly for its high titanium content, and its principal uses at present are in the coloring of porcelain and of artificial teeth and in the manufacture of some forms of arc lamps.

THE REPAIR OF FARM EQUIPMENT.*

IDEAS FOR THE HANDY FARMER.

BY W. R. BEATTIE.

The successful management of a modern farm depends largely upon the efficiency of the equipment with which the work is performed. The equipment of the average farm can be divided into about three more or less distinct classes, as follows: First, and most important, are the buildings, fences, implements, machinery, wagons, and all appliances used in the

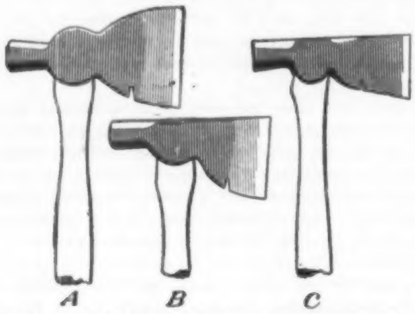


Fig. 1.—THREE TYPES OF HATCHET.

The half hatchet, *B*, is best adapted for general farm use.

more important farming operations; second, utensils and machinery used in connection with the dairy, garden tools, butchering outfit, and the numerous small things for general use about the place; third, the tools, materials, and facilities for keeping the first two classes of equipment in repair and in good working order. It is with the last class that this paper has to deal, the object being to assist the farmer in the selec-

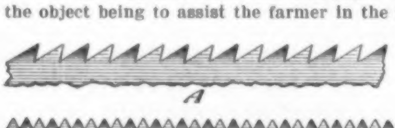


Fig. 2.—SAW TEETH.

A, ripping saw; *B*, crosscut saw.

tion of a suitable tool outfit, to suggest a line of supplies that are most commonly required for making repairs, and to give hints regarding the proper care and uses of tools.

In order to secure the greatest efficiency, all implements and machinery should be properly housed when not in actual service, so as to be in good working condition when required for use. Alterations and repairs on buildings and fences are required from time to time to accommodate them to changed conditions and to protect the crops. Farm machinery and equipment generally are subject to wear and breakage, and con-

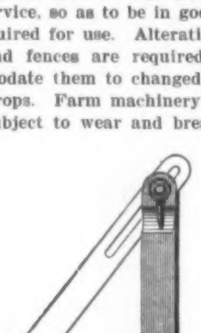


Fig. 3.—BEVEL SQUARE.

stant attention to repairs is necessary. The extent to which the repair work should be done on the farm will depend entirely upon local circumstances. If there is a well-equipped shop near-by where the repair work can be done by a trained mechanic without loss of time it may be best to carry the greater part of such work to the shop; but if the shop is at a distance, is poorly equipped, or, as is often the case, the mechanic in charge is incapable of turning out good work, it will then be a saving to perform the work at home. Besides, there is a large amount of repair

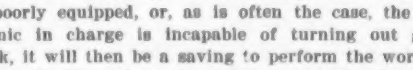


Fig. 4.—CLAW BAR.

work that can not be carried to a shop and must be done on the farm if it is done at all.

The Importance of Making Repairs Promptly.—Breakdowns are most frequent during the busy season, and much valuable time may be lost in going to some distant shop for repairs or in waiting until a new part of such machine or implement can be secured. In many cases an accident to one of the farm implements will cause the loss of not only a portion of the crop but also the time of a number of farm hands until repairs can be made and work resumed. Permanent repairs can frequently be made at once, and under most circumstances temporary repairs, at least, can be made, provided the necessary tools and supplies are at hand.

The Economy of Making Repairs on the Farm.—

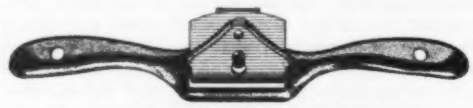


Fig. 5.—SPOKESHAVE OR SCRAPER.

The question as to how far to undertake to do repair work on the farm will depend considerably upon the personality of the farmer himself and his capability to handle tools and execute the work. The regular work of the farm should be the primary consideration, and any repair or construction work that will cause the neglect of crops should not be undertaken. By the aid of a little training, together with the necessary tools and supplies, the farmer can repair all ordinary in-

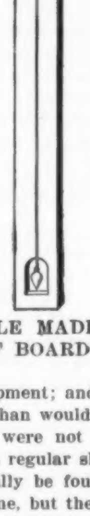


Fig. 6.—PLUMB RULE MADE FROM A PIECE OF BOARD.

juries to the farm equipment; and as a rule he can do this in a shorter time than would be required to go to a distant shop. If it were not for the economy of time, repairs made in a regular shop and by a trained mechanic would generally be found more satisfactory than those made at home, but the saving in both time and expense renders the repair outfit an important adjunct to the farm equipment.

The Time for Making Repairs.—Much of the loss

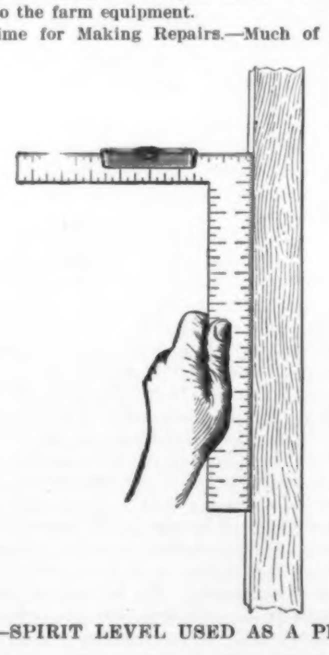


Fig. 7.—SPIRIT LEVEL USED AS A PLUMB.

and annoyance from breakage may be avoided by carefully inspecting and mending weak parts of the farm equipment before the rush of the season's work begins. The proper time for making such repairs as may be anticipated is during the winter months and at times when the regular farm work is not pressing. As the season advances the implements that will be required for the next farming operations should be gotten out, gone over, and given any attention required to make them ready for immediate use. If the farm machinery is not properly housed through the winter or during other periods of disuse, then it is all the more important that it should be given a careful overhauling. After inspecting an implement, tightening bolts, strengthening weak parts, and renewing broken

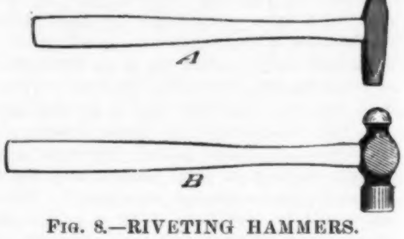


Fig. 8.—RIVETING HAMMERS.

A, Ordinary riveting hammer; *B*, machinist's hammer.

pieces, any necessary painting should be done. Frequent applications of dark red metallic paint, consisting either of red lead or Venetian red and raw linseed oil, not only improve the appearance of many of the farm implements but add greatly to their lasting qualities. This is an age when appearances count for much, and a farmer's standing in the community is frequently governed by the appearance of his farm equipment. The man who spends his spare moments in the repair of fences and gates and in maintaining a neat appearance of the entire farm will easily be a leader among his neighbors.

The Educational Value of the Use of Tools.—The use of tools is of great value as an educational feature, especially when the work is carefully performed. The boys on the farm should be encouraged in the use of tools, but should be held responsible both for the care of the tools and the character of the work performed with them. The tool outfit of the farm is of special service on stormy days and will aid greatly in keep-

Fig. 9.—SOLID, OR "S," WRENCH.

ing the boys employed and contented to remain at home.

Before beginning any piece of work, a definite plan should be worked out in detail, and if it requires the assembling of several parts each piece should be sketched on paper or on a board, so that when finished a close fitting of parts will be assured. It may be well to add a word of caution regarding the improper use of tools, for constant tinkering will work more harm than good. If a bolt is tight, that is sufficient, and an extra turn with the wrench may strip the threads and cause trouble. The taking apart of machinery should be avoided, except in cases where it is absolutely necessary to do so. The reaper and mower and other machines of this class are securely put together at the factory, and if the parts are removed it is difficult to restore them to their proper adjustments.

It is doubtful whether horseshoeing,* wheelwright

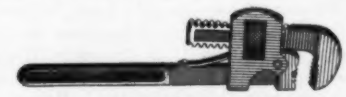


Fig. 10.—PIPE WRENCH.

work, and repair work which requires special machinery can be economically performed on the farm, except where the farming operations are sufficiently extensive to justify the establishment of a shop and the employment of a mechanic.

* Reprint of Farmers' Bulletin 347, published by the Department of Agriculture.

* For information on horseshoeing, see Farmers' Bulletin No. 179, which will be sent free upon request to the Secretary of Agriculture.

TOOLS ADAPTED TO REPAIR WORK ON THE FARM.

The selection of the tool outfit will depend upon the scope and character of the work to be performed.

On most farms there is a deficiency of suitable repair tools and supplies, and an increased investment along this line is strongly recommended. Some farmers, however, need to be cautioned against hasty, indiscriminate purchases. A small, well selected outfit,

FIG. 11.—PORTABLE FORGE.

used to the best advantage and well cared for, will prove more satisfactory than a large miscellaneous assortment improperly kept and used.

In this bulletin no attempt is made to determine the extent of the repair outfit which the individual farmer should purchase or the amount and scope of the work he should undertake. The problem is one for each farmer to solve, as he alone is familiar with all the

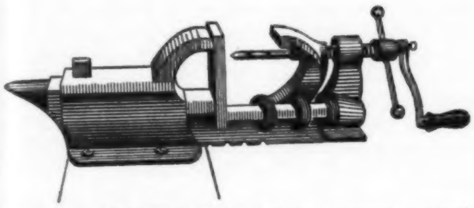


FIG. 12.—COMBINATION VISE, ANVIL, AND DRILL.

conditions. The aim here is to furnish information which will be useful to farmers of all classes in selecting repair outfits, whether they be large or small, leaving each farmer to decide the extent to which he should purchase and use the tools and supplies listed.

In nearly all localities most of the tools may be purchased from the local hardware dealer. In many places there are stores known as "farmers' supply

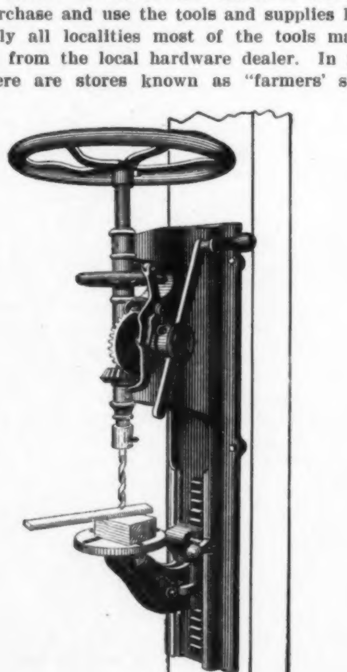


FIG. 13.—STANDARD DRILL PRESS.

houses" from which many of the more common tools may be purchased. In addition to these, many of the manufacturers of tools offer combination outfits, and the large "mail-order" houses of the country are prepared to supply tools of all kinds, either singly or in combinations. A number of tools and appliances described herein are not ordinarily found in the regular stores, and these can be made either by a local mechanic or on the farm.

Under most circumstances it will pay to secure tools of good quality, although fine exterior finish is not essential. Tools of very inferior quality are offered at low prices, but they invariably prove a disappointment to the purchaser. The name of the manufacturer may be a sufficient gage of the quality of many tools, but the purchaser is advised to secure only those that are sold under a guaranty from either the manufacturer or the dealer. When contemplating the purchase of a collection of tools, make a careful study to see just what ones are needed, then purchase all at

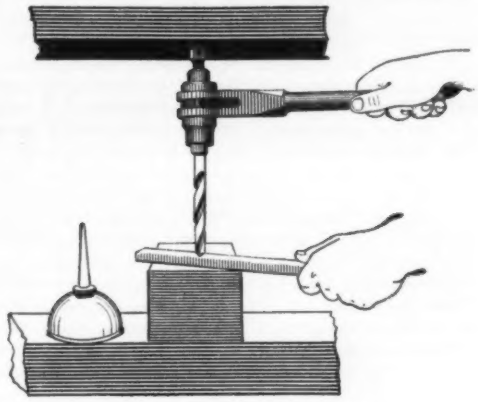


FIG. 14.—RATCHET DRILL.

one time, and a liberal discount can generally be secured.

For the convenience of intending purchasers in making up a set of tools, lists with descriptions of those most commonly required on the farm are here given; also suggestive combinations varying in price from $2.50 to $25. In describing the tools, they have been divided into classes, including wood-working, iron-working, miscellaneous, and general-purpose tools, and special conveniences for repair work. In making up the lower-priced combinations, preference is given to the tools required for the more simple operations and having a broad range of utility.

WOOD-WORKING TOOLS.

In the case of certain tools more than one shape or style is offered by dealers. In a few cases a particular type of tool is better adapted to use on the farm than others, and these differences are mentioned in connection with the following list.

Ax.—An ax is perhaps one of the first tools required upon a farm. The ax properly belongs to the regular farm equipment, but inasmuch as an ax which is used for general purposes on the farm is rarely in condition for use in making repairs, it is recommended that at least two axes be on hand, one to be kept in first-class condition and to be used for repair and construction work alone. Axes are of various grades and range in price from 75 cents to $1.50. Axes also vary in weight between 2 and 5 pounds, 4¼ or 4½ pounds being a good size for general use. It always pays to secure a good ax, and a hand-made hickory handle is to be preferred to the cheaper machine-made ones.

Hand Ax.—The tool commonly known as a hand ax is similar to a large hatchet or, rather, is a compromise between a hatchet and a broadax. The blade of

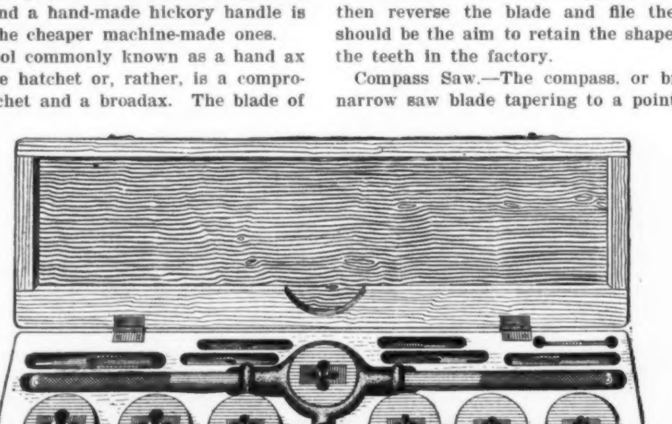


FIG. 17.—SCREW PLATE.

the hand ax is ground on one side only, and it is especially adapted for use in hewing the side of a post and for "roughing out" doubletrees, tongues, and similar parts of machinery.

Hatchet.—A hatchet is almost indispensable on the farm, even where the tool outfit is very limited. There are several styles and shapes of hatchets on the market, the half-hatchet (Fig. 1, *B*) being perhaps the most serviceable type. There is no tool where quality counts so much as in the hatchet; however, a good one can be secured for about 75 cents.

Handsaws.—A good handsaw is almost as important on the farm as an ax or a hatchet. A crosscut saw, having regular V-shaped teeth, is most often required, but a ripping saw will be desirable where a large amount of lengthwise sawing is to be done. The difference in the shape of the teeth of the crosscut and ripping saws is shown in Fig. 2. A crosscut saw for general farm purposes should not be too fine, one having about 8 teeth to the inch being desirable. If more than one saw of this class is kept, the collection should include a No. 7 or No. 8 for the rougher work

FIG. 15.—CHAIN DRILL.

and a No. 11 for finer cutting. A large-toothed crosscut saw can readily be used in place of a ripping saw, especially if the teeth are filed a trifle on the order of those of the ripping saw.

The proper sharpening of saws is essential, and unless one has had considerable experience it will be desirable to have this work performed by a trained mechanic. The saw-sharpening outfit consists of two thin boards between which the saw blade can be clamped in the vise or workbench clamp, a "set" for use in giving the teeth of the saw the proper spread, and a small three-cornered file. First go over the

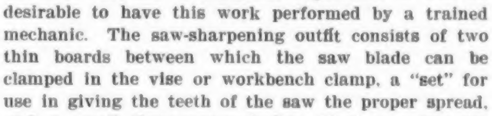


FIG. 16.—HACK SAW.

The thread for tightening the blade is located in the handle.

teeth of the saw with the "set" and open them just enough to give the blade clearance in the wood, being careful to spread the teeth in the same direction as they were originally. After having properly opened the teeth proceed to sharpen them with the small three-cornered file. Hold the file with both hands, at a slight angle with the saw, and draw it about twice through each notch between the teeth. File one side of the saw at a time, skipping every other notch; then reverse the blade and file the other side. It should be the aim to retain the shape and pitch given the teeth in the factory.

Compass Saw.—The compass, or bracket, saw is a narrow saw blade tapering to a point. The principal uses of a compass saw are for cutting curved surfaces for the timber parts of implements, sawing circular openings, and sawing a slit from an auger hole in which the regular handsaw may be started.

Steel Square.—For most purposes a square having a length of 24 inches on one arm and 16 or 18 inches on the other arm will be found satisfactory. For lighter work a medium-sized square is convenient, and for very small and careful marking the try-square, measuring about 4 by 6 inches, is desirable. The standard-size square will be found most important, and this can be secured at prices ranging from 75

cents to \$1.50, or even higher. A small try-square can be purchased for 25 to 30 cents.

Bevel Square.—The bevel square (Fig. 3) is a device one blade of which can be set at any angle to the other. This tool is useful where a number of pieces of material are to be cut to a given slope, the siding for the gable end of a building being a good example. The cost of a bevel square should be about 40 cents.

Drawing Knife.—The uses of this implement on the farm are too well known and numerous to require mention. The essentials of a serviceable drawing knife are good steel in the blade and substantial handles securely riveted. A first-class drawing knife adapted to general purposes can be secured for about \$1.

Brace and Bits.—For boring holes not exceeding 1¼ inches in diameter, a brace and a set of bits are essential. There are several types of brace upon the market. The simpler forms can be secured for 40 or 50 cents each, while the more elaborate types with ball bearings and ratchet shank frequently sell as high as \$2.50. For ordinary work the cheaper form of plain brace will answer, but for boring in close quarters a ratchet brace that will work without turning the handle completely around is desirable.

The bits for use in the brace can be secured singly or in sets of 6, 8, or 12, including sizes ranging from ¼ inch to 1¼ inches. A set containing eight bits will answer practically every requirement on the farm. The set containing twelve bits includes sixteenth-inch sizes and can be secured at prices from \$2.50 upward. The brace and a full set of bits should not cost more than \$5.

Gimlet Bits.—For boring small holes in wood, especially for the insertion of wood screws, an assortment of gimlet bits is desirable. The uses of the gimlet bits are limited, however, and their place may be filled by the small sizes of twist drills which may be used for boring either wood or metals.

Screw-driver Bit.—For setting wood screws in hard wood or for the removal of old ones there is nothing equal to a square-shank screw-driver that may be used in the brace. This little tool can be made from the shank of a broken carpenter's bit, from an old file, or a small piece of steel, or it can be purchased for 10 cents.

Screw-driver.—The common hand screw-driver is especially desirable for use about the dwelling and for light work on machinery. In order that a screw-driver should give good service it is essential that the metal part should consist of good steel and that it should extend through the handle and be securely riveted. The handle should also be protected from splitting by means of bands or rivets. This type of tool can be secured at prices ranging from 25 to 75 cents, according to size and quality.

Augers.—For boring holes larger than 1¼ inches in diameter it will be necessary to secure regular augers having T-style handles. By having the square shank of the augers of the same size and provided with a thread and nut at the end, one handle can be made to serve for all. There are handles on the market which are provided with an iron plate and thumb-screw for clamping to the auger shank.

If the cutting edges of an auger or a bit become dull, they may be sharpened with a small file. To merely sharpen an auger, file on the lower side of the cutting edges, being careful to keep them of the same pitch or bevel. In case a bit does not take sufficient hold, first see that the threads on the center point are clean; if the difficulty is not with the threads, then file the upper side of the cutting edges a little.

Jack Plane.—The name "jack plane" is applied to that class of planes that are suited for general purposes, especially for rough work. The old form of wood-body jack plane with its wedge-set bit has been largely replaced by the modern iron or combination wood and iron plane, with spring and thread feed to regulate the bit. A very good 14-inch jack plane can be bought for \$1.50.

Smoothing Plane.—This tool is similar to the jack plane except that it is smaller and is designed for imparting a smooth finish after the rougher surface has been removed. The cost of a smoothing plane will be about \$1.25.

In grinding the bit of a plane care must be taken to keep the edge square and to prevent the corners from becoming rounded. It is well to have a small square at hand and try the edge from time to time while grinding. After grinding the plane bit always finish on an oilstone, smoothing off any burr or rough edge that has been formed in grinding. Do not grind the plane bit every time it loses its keen edge, but simply whet it on the oilstone; grind it only when the oilstone fails to give a cutting edge. In resetting the bit in its place, first have the cutting edge of the bit a little higher than the lower surface of the plane, then after clamping it in place gradually feed it downward until the proper depth of cut is reached.

Wood Chisels.—A number of chisels of sizes from one-half inch to 1½ inches are desirable. The type known as "socket and firmer," with a leather tip on the wood handle, is the best for general purposes. The price will vary with the size and quality from 25 cents to \$1.50 each. A wooden mallet should be used for driving the chisels.

Claw Hammer.—This common type of hammer is desirable for use around the house and outbuildings. The principle of construction gives great leverage for drawing nails. If a spike or long nail is to be drawn, the efficiency of the claw will be greatly increased by placing a rounded block of wood between the hammer and the plank from which the nail is being drawn. A medium-grade claw hammer can be secured for about 50 cents, but one of the highest quality will cost 90 cents to \$1.

Claw Bar.—Where a great many large nails are to be drawn or where old buildings are to be torn down, there is nothing superior to a claw bar (Fig. 4). This tool can be made by any blacksmith from a piece of ¾ or ⅞-inch steel about 3½ feet in length. One end should be shaped somewhat like the claw of a hammer with a wedge-shaped slit for taking hold of nails. The opposite or handle end may be drawn to a chisel point, and serve as a bar for the prying apart of materials; or if drawn to a sharp point it is very useful for drawing staples. The length of handle and short fulcrum of this tool give a powerful leverage when applied to the pulling of spikes or bolts.

Spokeshave.—The spokeshave (Fig. 5), sometimes called a scraper, has been in general use for a long time and is still one of the most useful tools, especially in the finishing of handles or anything that is shaved from wood. A good one can be purchased for 40 cents.

Wood Rasp.—The wood rasp is similar to a coarse file and is used for finishing any piece of wood which requires to be brought to a definite size. A wood rasp is desirable for use in fitting the handles of picks, mattocks, or hoes to their sockets. A 14-inch wood rasp will answer general purposes and should cost about 35 cents.

Folding Rule.—Where some measuring device is frequently wanted, a folding rule that can be carried in the pocket will be found very convenient. Folding rules are made in lengths from 1 to 5 feet and can be secured as cheaply as 10 cents each, but one that will prove durable will cost 35 or 40 cents.

Chalk Line.—Any hard-twisted string will serve as a chalk line. Cord made especially for this purpose can be secured for 10 or 15 cents a ball. Chalk for use on the line can be purchased for 5 cents a ball, or about 15 cents a pound. A chalk line is especially desirable for securing a straight cut through a plank having irregular edges and in "laying off" a tapering tongue or similar part of farm machinery.

Plumb Rule.—A plumb rule is desirable for use in construction work and is also adapted to the setting of posts. A device of this kind (Fig. 6) can be made from a piece of board, a bob, and a string.

Spirit Level.—This implement will be found useful for a great many purposes. The most common form of spirit level consists of a bar of wood with a spirit tube mounted near the center. In the better grades a plumbing tube is inserted near one end. Levels of this kind cost from 40 cents to \$1.50 each. There is a small, or pocket size, level (Fig. 7) that is adapted for fastening on a steel square and may be used either for leveling or plumbing purposes. This form of level can be bought for 15 or 20 cents.

TOOLS AND EQUIPMENT FOR WORKING IRON.

The following list, together with short descriptions, includes the majority of the tools that will be required for handling metals in the repair of farm equipment. There are a few tools that are equally useful for working with both wood and metals; for instance, twist drills may be employed for boring almost any kind of material.

Riveting Hammer.—A good riveting hammer is essential on every farm where modern machinery is used. There are two types of riveting hammer in general use (Fig. 8), one having one end of wedge shape and the other type (known as a machinist's hammer) having a round end for riveting purposes. The hammer having the wedge-shaped riveting end is generally considered best for farm purposes.

Monkey Wrench.—A monkey wrench frequently accompanies one or more of the farm machines, but as this is one of the most important repair tools an extra one will not come amiss. The size of this tool is determined by its length in inches, a 12-inch monkey wrench being adapted for most purposes. The type of wrench having the wood handle in two parts and riveted to the central iron handle is most serviceable. A 12-inch monkey wrench will cost about 60 cents.

Solid or End Wrenches.—For many purposes the solid type of wrench (Fig. 9) with end jaws fitted to the various sizes of bolts and nuts is desirable. Those made somewhat in the shape of the letter S are adapted to working in close places and are not likely to slip. These wrenches may be purchased at prices ranging from 7 to 35 cents each, or they may be made from steel and slightly hardened.

Alligator Wrench.—The alligator wrench is very desirable for holding a round-headed bolt or rod of iron; also for turning nuts that are inaccessible for an ordinary wrench. Alligator wrenches having one jaw adjustable are obtainable, but the form having both jaws rigid is somewhat cheaper. The cost of a small alligator wrench will be anywhere between 15 and 60 cents, according to quality and finish.

Pipe Wrench.—A pipe wrench of 10-inch or 12-inch size is quite desirable for use in making repairs upon farm machinery. The pipe wrench (Fig. 10) is adapted for turning or holding iron pipe, rods, or bolts. It is essential to have one or more pipe wrenches on farms where a water supply under pressure and general plumbing appliances are maintained; however, wrenches for pipe fitting should as a rule be somewhat larger than those used for repair work on machinery. The cost of a small pipe wrench suitable for repair work should be about \$1. Neither the pipe wrench nor the alligator wrench should be used extensively for turning the nuts of bolts, as the teeth of these wrenches tear and injure the nuts.

Punches.—An assortment of punches, including several sizes and kinds, should be kept on hand. The round, solid-point punch, adapted to such work as punching out the rivets of the ordinary mowing-machine knife, is the most important, although those having square and taper points are frequently required. The collection should include a center punch having a blunt, sharp point for marking metals before drilling.

An assortment of punches may be purchased at a cost of from 10 to 40 cents each, or they may be made from tool steel by a blacksmith.

Cold Chisels.—For general-purpose repairing an assortment of various sizes of cold chisels should be kept on hand. These tools belong in the same class as the punches and can either be purchased or made from tool steel. The cost of cold chisels varies according to the amount of steel that they contain, the smaller ones being sold as low as 15 cents and the larger ones from 40 to 60 cents.

A chisel for use in cutting hot iron known as a "hardie" (shown in place on anvil, Fig. 12) is designed to fit the square hole in an anvil, the iron being laid upon the upturned edge of the hardie and struck with a heavy hammer. Another type of cutter fitted with a handle is offered by the trade. In using this tool the iron is placed upon the anvil, the cutter is held in position, and the cutting is done by striking with a sledge or heavy hammer. The cutting edge of any chisel for cutting iron requires to be tempered very carefully in order that it may withstand hard usage.

Files.—Both flat and three-cornered files will be required quite frequently in making repairs or improvements to equipment. A large flat file can be secured for 30 or 40 cents, and the small three-cornered ones will cost only 10 or 15 cents each. In securing a large flat file it is desirable that it should not be too fine, one of the flat bastard type being the most serviceable. The three-cornered files can be secured with single or double cutting ends. Square and round, or rat-tail, files are useful for many purposes.

Forge.—There are numerous makes of portable forges on the market, practically all of which are adapted to use on the farm. This type of forge is desirable where it is necessary to do work in several localities; but where the repair work can all be brought to a central shop a stationary forge with rotary blower will be found most satisfactory. Portable forges (Fig. 11) can be secured at prices ranging from \$3.50 to \$15, a good outfit being obtainable for about \$8. A blower with connections for a stationary forge can be bought for \$10 to \$15.

Anvil.—Some form of anvil is of as much importance as the forge. Anvils are made in various sizes and are sold by weight. Two types of anvil are offered by dealers, the one consisting entirely of wrought steel and the other of cast iron with a steel facing. The wrought anvil, although more expensive, is to be preferred to the cast-iron type, as there is no danger of its breaking under heavy forging. An anvil suited to repair work should weigh from 70 to 90 pounds. The cost of a cast anvil will be about 3 cents a pound and of the wrought-steel anvil 10 or 11 cents a pound.

Where no regular blacksmith outfit is maintained, a combination vise and anvil will be found fairly satisfactory. The anvil should be mounted on a heavy block of wood, but in order that it may be moved when necessary it should not be anchored to the floor.

Blacksmiths' Hammers.—A forging hammer weighing about 2 pounds will be desirable for working hot iron on the anvil. This tool will cost from 80 cents to \$1.

Where considerable heavy ironwork is to be performed, it will be desirable to secure a sledge hammer weighing about 8 pounds, to be used by the person assisting the blacksmith. This tool is known as a "striking" hammer. The cost of an 8-pound sledge complete with handle will be about \$1.

Tongs.—At least two pairs of tongs will be required for blacksmith work. If more than two pairs are provided the collection should include those having broad, flat jaws, also straight and curved-lip tongs. The size

of tongs is determined by their length in inches, the 20-inch length being about right for general purposes. The cost of tongs of this character should not be more than 50 cents a pair.

Vise.—Where considerable forging is to be done a regular blacksmith's vise with wrought-steel jaws is desirable. This type of vise will withstand the heavy hammering necessary to the bending and shaping of iron. For general purposes the cast-iron type known as a bench vise will answer, and this can be procured at a much lower cost than the regular steel vise. A combination pipe-holding and bench vise can be obtained, but the cost of such a tool is almost as great as for both a bench vise and a pipe vise when made separately. A very fair bench vise can be secured for $3.50, a wrought-steel blacksmith's vise will cost about $5.50, and a pipe vise that will hold all sizes of piping from 2-inch down to the smallest can be obtained for $3.

Combination tools (Fig. 12) intended to do the work required of a vise, anvil, and drill press are upon the market, but the separate tools will always be found most convenient and durable. A combination tool of this character can be obtained for about $4.

Drill Press.—Where extensive repairs are to be undertaken, there is no part of the repair outfit more desirable than a good drill press. The possession of some device by the use of which bolt and rivet holes may be drilled in metals renders possible the repair of almost any broken part of an implement. There are several forms of drilling machines upon the market, but a standard drill press (Fig. 13) will prove most satisfactory. A machine of this class is suitable for all ordinary purposes and can be secured, exclusive of drills, for about $10. There is a great difference in the quality of drills, but a fairly good set including 3/16, 1/4, 3/8, 7/16, 1/2, 5/8, 3/4, 7/8 and 1 inch sizes can be secured for about $5, making the price of the whole outfit $15. A lower-priced outfit is obtainable, but the drill press is a machine which with proper care should last a long time, and it pays to secure a good one.

As a rule the drill press is designed for mounting on a solid post, preferably a support of the building in which the shop is located. In operating the drill press place a small block of wood upon the bedplate and beneath the metal to be drilled. Before starting to turn the drill see that its point is in the center-punch mark, which indicates the location where the hole is to be drilled, and that everything is both level and solid. The drill should be turned slowly and fed downward with regularity. Care must be taken when the drill breaks through the metal that the drill itself does not bind and become broken. When drilling holes in pieces of metal that are too short for holding firmly with the hand, a clamp should be used and the piece of metal fastened firmly to the bedplate.

No one except an expert at grinding should attempt to sharpen the drills, as they must be ground to a particular bevel in order to cut properly. It is best to take them to a machine shop from time to time and have them dressed. Certain drills, such as 1/4, 3/8 and 1/2 inch, are used more often than the others, and it is desirable to have extra drills in these sizes on hand.

In boring wrought iron or soft steel plenty of good oil should be used upon the drill to prevent its heating. Hard steel should not be drilled, or at least not without first removing the temper. Cast iron, brass, and composition metals can be drilled without the use of oil. Always make an indentation with the center punch before starting to drill a hole; this provides a starting point for the drill and insures getting the hole in the proper place.

Ratchet Drill.—The place of a drill press may in a measure be filled by the employment of a ratchet drill (Fig. 14). This device has the advantage of being portable, and it may also be worked in close quarters where the use of a drill press would not be practicable. In using a ratchet drill as a substitute for the drill press it will be necessary to provide a solid frame for holding it, as shown in Fig. 14. A common boilermaker's ratchet is obtainable for $4 or $5, but the square-shank drills for use with it are more expensive than the common round and taper-shank drills used in the drill press. The ratchet-drill outfit is not adapted for boring holes that are below three-eighths inch in size, owing to liability of breaking the drills.

Chain Drill.—A small chain drilling outfit which works in an ordinary carpenter's brace is desirable for light work. This device is especially adapted to the drilling of tire-bolt holes and similar work not exceeding three-eighths of an inch in diameter. An outfit of this kind, as shown in Fig. 15, will cost about $2 exclusive of drills.

Twist Drills.—Regular drills for use in boring metals can be secured having square shanks that fit in an ordinary carpenter's brace. These drills are adapted for boring either wood or metals, and are much more durable for rough work than are the regular wood-boring bits. Twist drills for use in a brace are especially desirable in the smaller sizes. The cost of these drills is from 10 cents upward, according to size and quality.

Hack Saw.—Under ordinary circumstances a bar or rod of iron can be cut evenly enough with a hammer and cold chisel, but where exactness is required a hack saw (Fig. 16) will be found desirable. As the little blades for cutting iron are very hard and brittle, it is necessary to set them firmly in the frame in order that there can be no chance of bending or buckling. In sawing iron, proceed as in sawing wood, except that slight pressure should be applied in the cutting direction only. The hack saw should be held firmly with both hands and a uniform movement of about 60 strokes a minute maintained. When the blade becomes worn or broken it may be replaced by a new one. The blades cost 8 to 10 cents each, and extra ones should be kept constantly on hand.

Soldering Irons.—For general purposes a 1¼-pound soldering iron will be found satisfactory. Where continuous work is to be performed two irons are necessary, in order that one may be heating while the other is in use. Soldering irons should be heated only in a clear charcoal fire or in a blue flame of gas, gasoline, or alcohol. Before using a soldering iron it is essential that the tapering copper point be filed or ground until bright, and then coated with solder by first dipping the brightened hot point into a little of the soldering acid and afterward rubbing over the solder. This process is known as "tinning" the iron, and is necessary in order to make the solder adhere to the copper and spread evenly. The iron must be retinned as often as the coating burns off. Soldering irons are sold by the pound, the price depending upon the market price of copper; however, the ruling price is about 40 cents a pound.

Thread-cutting Appliances.—A set of stocks, dies, and taps for cutting threads on bolts and inside of nuts is quite desirable. This combination is termed a "screw plate" (Fig. 17) and ordinarily includes all sizes from 1/4 inch to 1 inch. The prices of these tools vary according to make and number of pieces in the set, but a very good outfit can be secured for $8 to $10.

A cheaper device, known as a blacksmith's stock and dies, may be secured for $2.50 or $3, but is not as satisfactory as the regular screw plate. In selecting a thread-cutting outfit care should be taken that the pitch of thread corresponds to that used on standard bolts and nuts.

Pipe-fitting Appliances.—With improved water-supply and plumbing fixtures it is possible for farmhouses and adjacent buildings to be equipped with modern conveniences. The work of installing the plumbing fixtures can all be done by the aid of a set of tools adapted to handling pipe and fittings. A set of pipe-fitting tools is essential to the employment of pipes in the installation of modern sanitary fixtures in dairy barns. A complete outfit for cutting, threading, and working pipe in sizes varying from 1/4 to 1 inch will cost about $10 for the simpler kind of tools, and these answer every requirement. This outfit would include stocks and dies, a pipe cutter, a pipe vise, and two wrenches. It should be borne in mind that in stating the sizes of pipes the inside, instead of the outside, diameter is given. The thread used on piping is different from that employed on bolts; consequently the dies for one are not adapted to threading the other.

(To be concluded.)

THE TREND OF INVENTION IN 1908.

THE position of industries generally can frequently be gaged by the manner in which inventors work during any year, for the records of the Patent Office in every country show that when there is a lull in trade improvements are introduced or new processes developed that receive no consideration from manufacturers and producers so long as there is a demand for the older types, and a steady output absorbed of that which has hitherto been considered the satisfactory form of device. Similarly, when manufacturers and principals of works find that there is a falling off or lessening in demand for that which has been previously considered a standard, the desire is quickened for improvements and for investigations that will tend to cheapen or produce a betterment in device in order that fresh life may be given to the industry, and a greater prosperity be induced.

To say that "necessity is the mother of invention" is a mere truism, but as a corollary to this there is the fact, known to everyone, that so long as manufacturers can sell what they produce, unfortunately only too often, the interests of the users are ignored. The whole history of, not one trade, but many, establishes the contention that British manufacturers as a class are not so alert in developing that which they produce as they should be, consequently opportunities are given to foreign rivals to introduce improved devices that will more efficiently meet the public demands.

The report of the British Comptroller-General of patents issued during the year 1908 forms an interesting commentary upon the trend of invention during that year, as indicated by the titles of applications for patents filed at the British Patent Office. The subject of locomotion appears to have occupied a very prominent position in the minds of inventors, and the continued interest taken in motor cars and the like mechanically-propelled vehicles indicates that such industry is still in the stage of progression. In the matter of wheels for such vehicles, although diminishing activity prevails, a large number of patents were applied for concerning the provisions of easily-detachable tire-carrying rims. Toward the end of the year many applications were received in connection with valves for internal-combustion engines, due probably to the interest taken by the public in the performance of the "Knight" engine. Attempts to abate the dust nuisance are shown in many inventions referring to machines for distributing tar upon the roads and for compositions for treating the surface of the roads, also for fitting attachable carriers to the cars for collecting such dust. The desire to facilitate roadside repairs to motor road vehicles has led to greater attention to the minor subject of tools, such as spanners and valve lifters.

That flying machines have drawn many patents is but natural, the type of "heavier-than-air" being evidently before the minds of a large body of workers, especially in regard to their automatic balancing and the facility of manipulation of the various rudders and planes.

In the textile industries the chief feature of interest concerned inventions for the prevention of accidents in connection with carding engines for cotton, while development of the industry for the manufacture of artificial silk was indicated by an increase of the large number of patents.

The submarine boat, while leading to patents for motors generally, has also been the cause of considerable activity for the solution of difficult optical problems in such instruments as short base range finders and "eyes" or periscopes.

Electrical subjects have in general fallen off in numbers, other than those concerned with the incandescent lamp and batteries. Railway signals of purely automatic systems and systems for giving signals in the locomotive cab still continue to show development, while a new feature has been apparent in the form of applications covering apparatus for controlling or stopping trains in the event of excessive speed.

In the industrial world the increased importance of India rubber is shown by the attention being given to processes for the regeneration of waste rubber, and the synthetic production of rubber or like products. Tungsten and like refractory metals have recently been made available for manufacturers by new methods of working them in alloy-like combination with ductile metals, which are afterward removed by heating the finished article.

It is interesting to note that notwithstanding the introduction of the Working Laws concerning patents that have originated from abroad, there were more patents granted to foreigners in 1908 than in the three previous years, when no working requirements were associated with the grant of British patents. This fact effectually disposes of the contention that the new patent act will act quite disadvantageously upon those foreigners who desire to obtain patents for their inventions in Great Britain.—The Practical Engineer.

A very ingenious method of rapidly cutting through an iron or steel plate has recently come into use. It is based upon the fact that when iron at a high temperature is acted upon by a fine jet of oxygen the resulting iron oxide is more fusible than the iron itself and passing away exposes a fresh surface of the metal to the attack of the gas, so that a cut is produced along the line of action. In the early attempts to utilize this method in practice, the metal was first heated to the required temperature in an oxyhydrogen flame, and then subjected to the action of the oxygen jet. Now, however, the heating and oxidation are done at the same time, and the resulting cut is much sharper. In one form of apparatus used for this process the metal is heated by means of an oxyacetylene flame, from the center of which issues a jet of oxygen. In illustration of the rapidity with which the process works, some experiments of M. L. Guillet may be cited. For instance, an armor plate 6¼ inches thick and 3¼ feet in length was cut in two in 10 minutes, while manholes could be cut in plates 3/4 to 1⅛ inches in thickness in 4 to 5 minutes. In parallel experiments upon the same piece of metal, a groove 1½ to 2½ inches deep was cut by the oxygen process in 7 minutes, whereas with a pneumatic chisel a groove of about the same length but only one-quarter as deep took an hour to cut. The new method has also given very satisfactory results in the rapid removal of the heads of rivets when plating has to be separated, only a few seconds' treatment being necessary for fusing off the head of a rivet 7/8 inch in thickness. With regard to the effect of the oxygen upon the metal adjoining the cut, experiments have shown that the depreciation is but slight.

A CHARIOT OF 3,300 YEARS AGO.

THE ANCIENT ORIGIN OF THE WHEEL.

BY JAMES ARTHUR.

If there is any branch of mechanical construction in which we feel sure of our modern advance, it is carriage wheels. Yet the Egyptians of 1400 B. C. used chariot wheels containing nearly all of our improvements. It is almost certain that they made bent-rim wheels with metal hubs and elastic tires long before that date. In the Cairo museum, that most wonderful collection of Egyptian antiquities, may be seen an ancient (funerary) chariot taken from the tomb of Iouiya and Touiyou about three years ago by Mr. Theodore M. Davis, an American who uses his time and wealth in advancing human knowledge by excavations in Egypt, instead of encouraging mendicancy and establishing "bread lines."

The wheels of this chariot are 30 inches diameter, and have bent rims in two pieces as shown, but the two pieces are not halves, as we make them. One of the pieces is about seven-eighths of a circle; the other *A A* (see diagram) being one-eighth. This is a most remarkable feature, and we are left to theorize as to its meaning. Perhaps the builder conceived the idea of a bent rim in one piece, but failed to make a satisfactory joint, and then put in the short section. The spokes are apparently without tenons, but are let into the rim full size just far enough to give a bearing for the end of the spoke, as shown enlarged in Fig. 2 at *G*. Practically, a rim of seven-eighths the circle could not be sprung over spoke tenons. Hence the necessity of the shallow entrance at *G*. The two joints of the rim are strengthened by the straps of bronze *A A*, just as we do to-day on light rims. The tire has a base of leather, over which a heavy leather band *F* is laced, and over this a fine leather band *E*, like parchment, is also laced. The hub is very long (about 16 inches) and is covered with bronze about as thick as a ten-cent coin. The spokes are a beautiful shape, about 1⅛ x ⅝ inch, but not exactly elliptical in section. They have shrunk a little, so that the joint at *B* would take paper as thick as this page. This adds to the impressiveness of the work, as it shows the spoke entering a metal hub. The curves *C C* of this hub could not be improved. The linchpin has a hole in its lower end, in which a leather thong *D* is tied. To this day that is the simplest and best method of preventing a carriage or cart from "throwing the linchpin." Axle *H* is wood and fastened to the rear of the body by bronze bands. The horseshoe-shaped rail of the chariot body is bent wood fastened at the joints with bronze straps. The floor of the chariot is made of leather bands ¾ inch wide, woven like our cane-bottom chairs. The rider stands on this floor, and has its elasticity along with that of the leather tires.

THE FRONT OF THE CHARIOT. HERCULES PRESENTING HIS HELMET AND SHIELD TO MINERVA.

ONE SIDE PANEL, REPRESENTING HERCULES KILLING LAOMEDON, FATHER OF PRIAM.

THE OTHER SIDE PANEL, REPRESENTING HERCULES KILLING ONE OF LAOMEDON'S CHILDREN.

THE ETRUSCAN CHARIOT IN THE METROPOLITAN MUSEUM OF ART, NEW YORK.

This wonderful chariot is completed by a long pole, and is kept under an immense glass case which has no doors. This case would require about eight men to lift it off, so there is no danger of visitors tampering with the exhibit. How are the curves *C C* formed? Are they worked on the spokes or the hubs, or both, or blocked in and worked on the blocking? I was unable to determine this, and probably it is not known, for the covering of the hubs appears intact and undisturbed. In a conversation with Brugsch Pasha, director-general of the Cairo museum, he informed me that all straps were imitation bronze—no metal in the chariot! This only adds to our wonder, for the imitation must be of chariots still older which were bronze trimmed. Remember, this is a "funerary" chariot, and that is just the reason we have it; for the metal-bound chariots for actual service were used up and have disappeared, while this one was safe in the rock-hewn tomb. Still more wonderful, what material is this imitation bronze, which would deceive any human being unless at liberty to test it with file and knife? The hub looks as solid, smooth, and free from cracks as the finest casting, and the general color and "tone" is that of old, rich bronze.

In the Metropolitan Museum of Art, New York city, may be seen the now famous Etruscan chariot taken from a tomb in Italy. As this article is primarily about wheels, the remarkable art work on this chariot is only casually referred to here. These wheels are about 30 inches diameter, and have noticeably long hubs, about 24 inches. The rims are 3 1/3 inches deep. It is pretty safe to assume that they are built in sections, or felloes, and not bent. They have nine spokes of circular section, tapering from 1¼ inches at hub to 1 inch at rim. These wheels are totally covered with thin bronze plate, and show extraordinary skill in hammering, fitting, and brazing the plates over the woodwork. They have iron tires or hoops, about 1¼ x ½ inch, large portions of which have rusted totally off. These rims are of oval section, as shown in Fig. 3, *J* being the iron hoop. These wheels are 600 B. C., and it is a remarkable feature that the wheels taken from the ruins of Pompeii, as well as those used to-day in the streets of Naples, have this form of deep rim with narrow tire and long hub. In other words, the regular, every-day wheels in Italy are substantially the same for 2,500 years. Also in the Metropolitan is a "processional car" in bronze having four wheels about 10 inches diameter and seven spokes, date about 200 of our era.

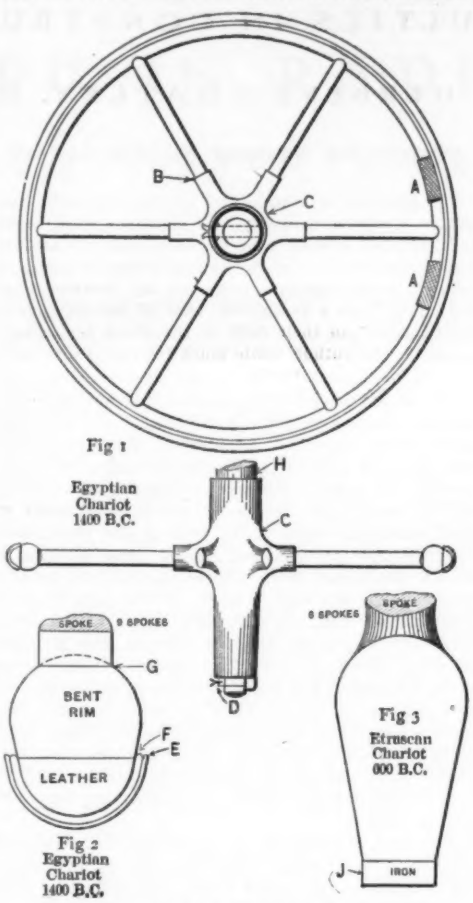
Now, about the number of spokes in these Etruscan and Roman wheels. It is hardly necessary to point out that these "odd" numbers, 9 and 7, must have been intentionally chosen, because it is more difficult to build odd numbers than even. That is, the builders took trouble to get the odd numbers in their wheels. Evidently, this question has not been much considered, as I was unable to get anything definite from museum authorities beyond the general statement that during a certain Grecian period odd numbers were general; but the reason is what I have been trying to find. A friend who knows something about both science and mythology suggests "three times three" for the nine spokes; for the seven spokes, the sacred num-

ber of days in our week and the "seven" and "seventy times seven" of the New Testament seem sufficient; for we must remember that this Etruscan chariot, as well as the Roman processional car, were built for religious processions. Finally, to those who might wish to go into this odd number matter a little deeper, I might say that I have a "sobba," or set of Mohammedan prayer beads, purchased in Constantinople, consisting of three sections, the string being three times thirty-three, making a total of ninety-nine beads; all of which is strictly to my text, "Chariot Wheels," and to many it may be more interesting than the mechanical part of the subject.

THE SCOPE OF EUGENICS.

IN a recently published letter Prof. Karl Pearson gives in this brief statement the whole eugenics argument: "The Darwinian hypothesis asserts that the sounder individual has more chance of surviving in the contest with physical and organic environment. It is therefore better able to produce and rear offspring, which in turn inherit its advantageous characters. Profitable variations are thus seized on by natural selection, and perpetuated by heredity." If these ideas apply to the case of man, "we must have evidence (1) that man varies; (2) that these variations, favorable or unfavorable, are inherited; (3) that they are selected." On the first head special evidence is hardly necessary; our own eyes afford evidence day by day that man varies, but there is plenty of definite knowledge also as to the amount and magnitude of variation. There is similarly a growing mass of evidence that such variations are not mere individual fluctuations, but are heritable. On the third head, however, the evidence is weaker and somewhat conflicting. In the population at large, natural selection appears to be operative to a greater or less extent, as we find that the age at death is inherited. It would be quite possible, however, for that selection to be ineffective if the weaker stocks nevertheless survived to a sufficient age to reproduce their kind as freely as the stronger stocks, and this seems to be the case to a large extent. The families of deaf-mutes, the tuberculous, and the mentally defective are as large as those of normal individuals, and the lower we go from one social grade to another the higher does the fertility rise. In these facts lies the stimulus to possible action directed toward the betterment of the race, negatively by placing hindrances in the way of the reproduction of the hopelessly unfit, positively by creating an altered tone and public spirit which may lead to a more normal and less restricted reproduction of the prosperous and the intellectual classes.

If one sentence may be cited with special approval, it is a statement near the commencement of the lecture: "Our science does not propose to confine its attention to problems of inheritance only, but to deal also with problems of environment and of nurture." The improvement of the environment is as much a method of improving the qualities of future generations as the method of selection, not, of course, because somatic variations are heritable (which we do not believe that they are), but because the improvement of the environment endures. In so far as housing, education, and the treatment of the diseased are improved in this generation, the next starts from a fresh basis. Eugenic and eugeic methods should aid each other, and racial improvement be based on care of both the seed and the soil. Hitherto the methods have been too often treated as if they were opposed.—Nature.



THE CONSTRUCTION OF CHARIOT WHEELS.

THE MOVEMENTS OF THE STARS.

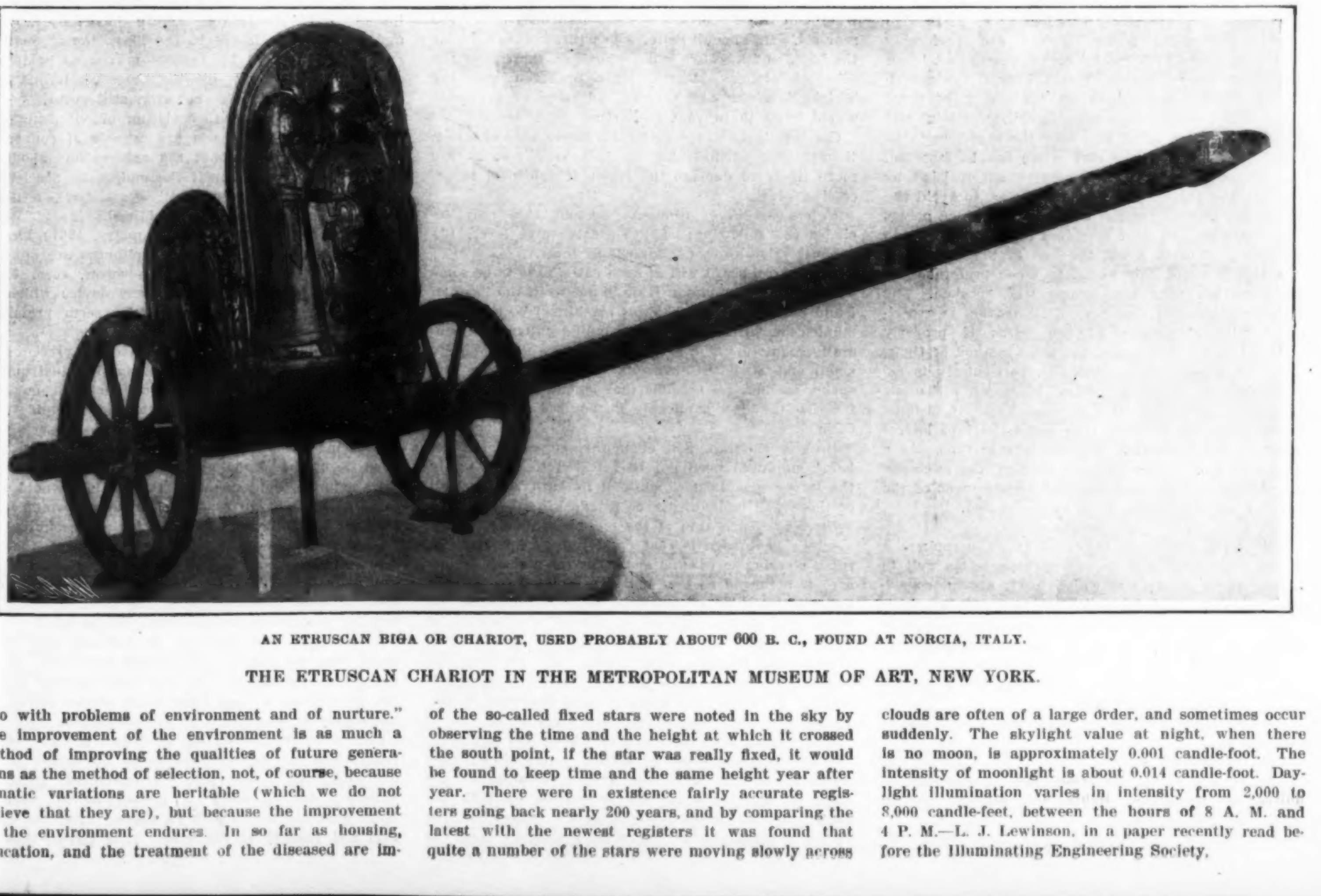
RECENTLY Prof. Poynting delivered his presidential address to the members of the newly-formed Astronomical Society, in the medical lecture theater of the University of Birmingham, on "How the Motion of the Stars is Measured."

Prof. Poynting remarked that if the position of one of the so-called fixed stars were noted in the sky by observing the time and the height at which it crossed the south point, if the star was really fixed, it would be found to keep time and the same height year after year. There were in existence fairly accurate registers going back nearly 200 years, and by comparing the latest with the newest registers it was found that quite a number of the stars were moving slowly across the sky. Such stars were said to have proper motion; but even when this proper motion was greatest it was exceedingly minute. One star, and that the most rapid, had moved about the diameter of the moon in the last 300 years. This motion was across the sky, and the telescope told us nothing of it. The study of the proper motion had shown that, on the whole, the stars were opening out from a point near Vega, and closing in to the opposite point. This could only be accounted for by supposing the solar system was moving toward Vega, or that the general body of stars were moving from Vega toward us.

Within the last two or three years, Prof. Kapteyn had found that the stars might be divided into two great classes, having on the average proper motions quite different in direction and magnitude, and he had explained this by the supposition that there were two systems moving through each other, one—the faster—from a point in the south of Hercules, and the other from a point in the Lynx. Our sun probably belonged to the latter group. To find the actual speed of travel we require the distance of the stars, as well as their proper motions. By noting the change in position, called the parallax, the distances of about a hundred stars had been measured, and these distances, combined with the proper motions, gave the actual rate of travel, which came out usually at something like ten or twenty miles a second. The motion in the line of sight was measured in an entirely different way by the aid of a principle discovered in 1842 by Doppler. He showed that the number of waves received per second would be altered by the motion of either the source or the observer. When the light from the stars was analyzed into a spectrum there were dark bands crossing the spectrum. These bands shifted when the star was moving to or from us, and Sir William Huggins, in 1868, first measured the shift, and so discovered the velocities of a number of stars to and from us. Again, the actual speeds were, as a rule, ten or twenty miles a second.

The most striking contribution to our knowledge given by the new spectrum method began in 1888, with the discovery that the lines of the variable star Algol moved to and fro. This was only explained by supposing that he and a dark companion are circling round each other, so that sometimes Algol is moving toward us and sometimes receding, the variations in his light being due to partial eclipses by the dark companion. The lecture concluded with an account of the system grouped around Mizar in the Great Bear, a component of which is like Algol, though both of the pair are bright.

Certain cloud formations have the effect of increasing the intensity of illumination by diffusion. Other clouds act as absorbing media, and decrease the illumination intensity. Variations in intensity due to clouds are often of a large order, and sometimes occur suddenly. The skylight value at night, when there is no moon, is approximately 0.001 candle-foot. The intensity of moonlight is about 0.014 candle-foot. Daylight illumination varies in intensity from 2,000 to 8,000 candle-feet, between the hours of 8 A. M. and 4 P. M.—L. J. Lewinson, in a paper recently read before the Illuminating Engineering Society.



AN ETRUSCAN BIGA OR CHARIOT, USED PROBABLY ABOUT 600 B. C., FOUND AT NORCIA, ITALY.

THE ETRUSCAN CHARIOT IN THE METROPOLITAN MUSEUM OF ART, NEW YORK.

AEROPLANE PROBLEMS.*

DIFFICULTIES IN CONSTRUCTION.

BY HERBERT CHATLEY, B.SC.

Concluded from Supplement No. 1742, page 327.

SEVERAL types (chiefly those used for gliding experiments only) have simply front vertical steering sets, consisting of single planes (e. g., Archdeacon) superposed planes (Bleriot-Voisin I) and box sets. It is essential in all cases that the steering planes shall be symmetrically arranged about the longitudinal axes.

The position of the propeller is another important point in this connection, and we have the following varieties of treatment:

(1) *Propeller, single and at rear.*—Santos Dumont XIV *bis*, Roe.

(2) *Propeller, single and in front.*—Bleriot VII, Esnault-Pelterie, Vuja, Santos Dumont XIX, Phillips (1908).

(3) *Propeller, single and between the sets.*—Farman I, Bleriot-Voisin I.

(4) *Two propellers between sets.*—Langley. This question is not yet settled by any means. The propeller at the rear has a free discharge, but, on the other hand, its feed is disturbed. In front it has a clear feed, but is hampered in discharging, and also modifies the streams impinging on the supporting planes. Also, by increasing the relative speed of the air, it causes considerable friction on those planes. Paired screws, if separately driven, would, of course, be very useful in assisting lateral steering, but involve complex and weighty mechanism. Centrally-placed screws are more likely to be fouled by broken tie wires, etc., and, if the propeller breaks, the machine may have its main girder destroyed. An important point in this connection is the position of the motor. If the propeller is in front while the motor is (on account, say of the form of the supporting planes) at the rear, there is a maximum of shafting and bearings, with consequent increase of weight.

Passing to the details of construction of the planes, in nearly all cases the great difficulty is permanence of forms. Generally, cross bars (bent to the curve of the plane) are fitted to the booms of the main girder, and stiffened by struts mortised through the cross bars, trussed to the ends of the bars by steel wire, and cross trussed to adjacent bars in the same way. The cross bars (which form, as it were, the ribs of the surfaces) should be as flat as possible, and the struts should be edge on to the direction of motion so as to present a minimum of resistance. In some cases they are nicely eased away so as to give roughly streamline forms. Joints are preferably solid, i. e., made with special socket pieces cast in an aluminium alloy. Messrs. Voisin Frères, for experimental gliders, recommend an "H" form of sheet metal, which can be bent round a trihedral joint and clamped with one small bolt over the members to be joined. To this bolt the stay wires can be fastened. The shearing forces in the girders are resisted by verticals and the stay wires. The latter, to avoid the use of the heavy, diagonal struts, are strained across both diagonals. In some machines the joints are made sufficiently solid to avoid the use of bracing wires. If weight permits, this would be much preferable, as the wires are very troublesome when broken. The author understands that very little trouble is experienced with slackening of the wires if properly arranged in the first place, but some method of tightening would seem to be essential, particularly to accommodate the slight permanent set which will occur during the first flight of a new machine. It is noteworthy that the dihedral type lends itself to lateral stiffening far more than the monoplanar type. As a matter of fact, in the author's opinion, the engineering skill shown in the structural arrangement of the Langley aerodrome cannot be overestimated.

ACCESSORIES.

This term covers in the case of an aeroplane a rather wide field, and it will perhaps be as well to specify those accessories which merit special consideration. They may be split into two groups: those forming an essential part of the machine, and those which are useful but not in all cases indispensable.

Among the former the author includes:

(1) Wheels and springs for starting and alighting.

(2) Motor-controlling gear.

(3) Steering gear other than the rudder planes themselves.

(4) Aeronaut's car.

The second group comprises the instruments required for navigation, lights, etc., scarcely any of which are yet necessary.

The question of wheels and springs for earth contact is a very serious one. All machines which have any claim to success have at some time or another been damaged to a greater or less extent in rising or falling. Some engineers, including Mr. Rankine Kennedy, take such a pessimistic view of the question of falling as to pin their faith to the direct acting hélicoptère. The author, while much interested and within certain limits believing in the efficacy of that machine, cannot nevertheless indorse this opinion. The gliding experiments made by Lilienthal, Pilcher, Chanute, Ferber, Herring, Archdeacon, Voisin, and Bleriot generally lead to the conclusion that a large proportion of gliding descents (without propellers in action) can be safely made. In the classical paper by Lord Rayleigh, delivered in 1900 to the Manchester Literary and Philosophical Society, this question is studied mathematically. The hélicoptère undoubtedly is safer while the engines work. If they stop it seems very unlikely that the parachutic action of the screw surfaces will prevent disaster, whereas with an aeroplane a degree of safety is assured. Nevertheless there is bound to be a shock when reaching the ground, and this must be mitigated to some extent. The springs must have an available stiffness at least equal to twice the weight of the whole machine, and they should come into action however the machine may descend. This latter condition it is, of course, very difficult to realize.

A general arrangement is to combine the wheel and springs in a somewhat similar manner to the mounting of a locomotive. Horn plates, attached to the main girder, carry the bearings of the wheels, helical springs being inserted between the upper bearing block and frame, so that, on impact, the springs are compressed by the bearing block rising between the horn plates. Seeing that, on descent, the machine is usually running forward, the horn plates might perhaps be advantageously inclined downward and forward, so that the resistance is, to some extent, in the direction of motion.

Solid rubber tires on wheels, about 12 inches in diameter, are sometimes employed. Capt. Ferber and M. Vuja use a four-wheeled central carriage. The Bleriot VII machine has three wheels, the odd one being at the rear. The Farman I machine has two large wheels in front planes, and two small ones under the rear set. M. Esnault-Pelterie has three wheels under the body, and also two small wheels on the tips of the dihedral planes. Messrs. Moore-Brabazon and the Wright brothers use runners, but this arrangement would seem to prevent re-starting after descent.

Carriage types of spring have a larger area of action than helical springs, but on this very account are more likely to damage the frame if subjected to excessive forces.

Motor-controlling gear.—At present this only includes the following: (1) Throttle valve lever, (2) exhaust valve lever, (3) air supply lever.

The control-board will in most cases have to be some distance from the motor (this is not so in the Farman I and Santos Dumont XIV *bis* machines) so that communication wires running over guide pulleys are generally required. The actual hand levers may be quite small and work in quadrants with stop grooves and spring catches. If possible they should all be so close together that one hand only is required for operating them.

Brakes, clutches, and change speed gears not yet being employed need not be referred to now, but in the larger machines which will be built some or all of these will undoubtedly be fitted.

Steering Gear.—One of the most ingenious arrangements I have seen is that employed by Mr. Roe. A small steering wheel and shaft (as for a small motor-car) is arranged so that it can be rotated on its axis and also work on a transverse axis. By drawing the wheel and shaft backward or forward the horizontal plane is rotated for vertical steering, the motion being transmitted through steel wires. By rotating the steering wheel, the same plane is twisted to steer laterally. A similar arrangement could doubtless be employed for controlling a vertical rudder plane.

In all cases, whether levers or wheels are employed, the arrangement must be double acting, i. e., have wires above and below the axis of rotation of the lever so that the wires are in tension on both the backward and forward movements. Otherwise stiff levers (necessarily of appreciable weight) must be used. In cases where a rod to transmit a thrust is indispensable, a fairly stout rod may be stiffened to resist crippling by fixing a cross of struts at its center, with stay-wires from the vertices to the ends of the rod.

Aeronaut's Car.—Although this may seem at first sight a minor matter, yet there are several very important considerations involved. A very slight movement on the part of the aeronaut causes a disturbing torque on the machine, so that it is essential that the car should be so placed that the controlling levers are easily accessible without moving the body. On the other hand, as aeroplanes are arranged at present, it is desirable that when necessary the body should be free to move so as to apply a torque to assist in steering. (Thus Mr. Farman found it necessary to throw his weight in different directions to perform various turning movements.) Further, the car should be so arranged that it is easy to enter and also to leave in the event of accident. On the other hand, there must of course be no chance of being thrown out.

Most machines have the car in the framing of the longitudinal girder. Its exact position will of course depend on the center of gravity of the machine without the aeronaut, for so long as the machines are of such size that the weight of an aeronaut has an appreciable ratio to the weight of the machine, his position will be of vital importance to the balance. Even a difference in his weight of a few pounds is now important, just as in balloons. It is, however, noteworthy that recently Mr. Farman and Mr. Delagrange have been able to ride together in Mr. Delagrange's aeroplane. Seeing that the weight of the aeronaut is thus variable, it would be well if the car could be placed at the general c. g. Under these circumstances the increase in weight will involve a higher soaring velocity, but will increase the stability, since the mass subject to disturbing torque is greater.

Among the appliances which may be necessary and form integral parts of the machine are balancing devices other than steering planes. The more important of these are (1) moving poise weights and (2) gyrostatic appliances.

The author has already referred to the poise weights used in the Weiss gliders, and he is inclined to think they may be made of much assistance in vertical steering. Operated by leading screws driven by a wheel and worm or by levers in the "lazy tongs" method, such weights could be rapidly moved to balance a disturbing torque or to provide a steering torque. The personal element would, however, still occur.

Gyrostatic appliances consisting of vibrating pendula or rotating flywheels are capable of converting a disturbing torque about the axis to one about an axis at right angles, or if the motion be accelerated (as in the Brennan monorail gyroscopes), a direct balancing torque may be obtained. Major Baden Powell (see letter to Nature, January, 1907) has expressed his opinion that such appliances are unnecessary. This opinion does not, however, seem to be universally held, and certainly any device which excludes the personal element would seem preferable for large machines.

Passing to the accessories which at the present time are not absolutely necessary, navigating instruments may first be referred to, and would include compasses, barometers, thermometers, anemometers, and wind vanes. Compasses are of course not necessary until much longer voyages are undertaken, but when used must be of the gimbal-hung type.

Barometers, on account of the motion, would need to be of the aneroid type. The readings would, however, be very difficult to correct for on account of the forced pressures and uncertain motion of the air. Anemometers would indicate the relative speed of the air, and wind vanes the relative direction. In conjunction with observations of the land, it would be possible to find the true direction of the wind.

The author will conclude by noticing that in no sense may we regard our present knowledge of the subject as exhaustive. As has been pointed out by Dr. Hele-Shaw, a long time must elapse before our knowledge of airships is at all comparable with that which we now possess as to ships. Before definite conclusions can be obtained as to the action of the air under all conceivable circumstances, great advances must be made in meteorological research. More accurate information is needed upon the direction and velocity of the wind. It is known that the

* Journal of the Royal Society of Arts.

air currents, by reason of the friction against the ground, have often a considerable vertical component, and Lord Rayleigh has shown that we must attribute to this fact much of the efficiency of bird flight. As to the velocity of wind, Prof. Langley's work on the "Internal Work of the Wind" and Sir Benjamin Baker's anemometer records at the Forth Bridge have considerably advanced our knowledge in this respect, but much has yet to be done by both scientists and aviators. It is quite conceivable that the pulsations in the air currents may be employed to increase considerably the mechanical efficiency of an aeroplane.

RECENT WORK IN RADIO-ACTIVITY.

SOME UNSOLVED PROBLEMS.

BY PROF. F. HENRICH.

THE hypothesis that all the chemical elements are subject to radio-active disintegration and transmutation is still unproven. New researches have shown that Ramsay was mistaken in assuming the formation of lithium and other alkali metals from copper under the influence of radium emanation. The lithium found by Ramsay was probably derived from the glass vessels or the reagents. Mme. Curie, having detected lithium in solutions previously free from lithium, which had stood twenty-four hours in either glass or quartz vessels, employed platinum vessels in repeating Ramsay's experiment. Even with this precaution she found it impossible to obtain a copper salt entirely free from lithium and was compelled to use a salt which contained enough lithium to be detected in the residue from two ounces but not enough to be detected in the residue from 30 grains. With this salt she repeated Ramsay's experiment (using the quantity employed by him) but obtained no trace of lithium or sodium. Ramsay obtained the same negative result on repeating his experiment with quartz vessels.

Uranium, actinium, and thorium, however, are continually disintegrating and producing derivatives, each of which possesses its characteristic coefficient of radio-activity, which is nearly independent of the temperature. This radio-active constant, λ; the number of radio-active atoms originally present, N_0; and the number left intact after t seconds, N_t, are connected by the equation $N_t = N_0 e^{-\lambda t}$, in which e is the base of natural logarithms. Hence λ represents the proportion of atoms disintegrated in one second, and $\frac{1}{\lambda}$ is the average life of an atom, while the "half period," in which one-half of the original substance is decomposed, is $\frac{0.69314719}{\lambda}$.

Uranium, actinium, and thorium are still regarded as the primary radio-active elements. Each produces its distinct series of derivatives, but actinium itself is suspected to be a derivative of uranium.

A new member, ionium, has been added to the uranium series. The short-lived uranium X was expected to yield perceptible amounts of radium or radium emanation in a few weeks, but Boltwood could find no trace of either after a year. Hence he suspected the existence of a long-lived intermediate product, which was subsequently separated by him, and by others, from uranium ore, and by Hahn from commercial preparations of thorium. This new substance, ionium, closely resembles thorium in its reactions. It gives off no emanation when freshly separated, but yields appreciable quantities of radium emanation after a few weeks. The uranium series, therefore, now stands as follows:

	Half Period.	Rays Emitted.
Uranium	6.8 billion years	α
Uranium X	22 days	β and γ
Ionium	?	α and β
Radium	2600 years	α
Emanation	3.75 days	α
Radium A	3 minutes	α
Radium B	26 minutes	β
Radium C	19 minutes	α, β and γ
Radium D	40 years (?)	None
Radium E_1	6 days	None
Radium E_2	4.8 days	β
Polonium	140 days	α
Lead (?)	....	....

The actinium series has not been changed since Hahn's discovery of radioactinium and now stands:

	Half Period.	Rays Emitted.
Actinium	?	None
Radioactinium	19.5 days	α
Actinium X	10.2 days	α
Emanation	3.9 seconds	α
Actinium A	36 minutes	None
Actinium B	2.15 minutes	α and β
Actinium C (?)	12 days (?)	?

In the thorium series mesothorium which, with radiothorium, was discovered by Hahn several years ago, has been resolved into two components, and a very short-lived thorium C has been separated from thorium B.

The series, therefore, now stands:

	Half Period.	Rays Emitted.
Thorium	More than 10 billion years	α
Mesothorium	7 years (?)	β
Radiothorium	737 days	α
Thorium X	3.64 days	α
Emanation	54 seconds	α
Thorium A	10.6 hours	β
Thorium B	55 minutes	α, β and γ
Thorium C	A few seconds (?)	α, β and γ

The positively electrified particles which constitute the α rays have long been suspected, and have now been virtually proved to be atoms of helium, bearing twice their normal electric charge. The α rays emitted by various radio-active elements differ in velocity and power of penetrating. The particles produce ionization in gases by colliding with the gas molecules, and thus their velocity is diminished. The distance traveled by the rays before their velocity is reduced to a certain constant value, at which ionization practically ceases, is called the "reach" of the rays, and affords a means of distinguishing between various radio-active elements. The α particles have been counted by ingenious methods.

During the past year the Vienna radium commission has extracted from some 40 tons of Joachimsthal pitchblende and uranium residues the equivalent of about 46 grains of radium chloride. The evolution of heat by radium has been found equal to 118 gramme calories per gramme of pure radium. An atomic weight of 226.4, derived from Mme. Curie's determinations, has been adopted for radium by the international committee. A new determination of the "half period" of radium gives the value 3.75 days.

Radium emanation is absorbed by various substances, especially carbon, which retains it completely up to 60 deg. F. Ramsay and Cameron have studied the action of the emanation on water, which it rapidly decomposes, though it has no apparent effect on water vapor. A little neon is produced in the process. Radium emanation also causes oxygen and hydrogen to combine and similarly it reverses, in some degree, its decomposing action on ammonia, hydrochloric acid, carbon dioxide, etc. It decomposes carbon dioxide into carbon monoxide and oxygen, and converts carbon monoxide into carbon, oxygen, and carbon dioxide.

Ramsay apparently obtained 7 cubic centimeters of emanation from 1 gramme of radium, which should yield only 0.4 cubic centimeter, according to Rutherford's calculation, assuming that each radium atom expels one α particle, which is converted into one atom of emanation. In seeking an experimental explanation of this discrepancy, Rutherford could not obtain a gas containing more than 20 per cent of radium emanation. He finds that the great fluctuations in volume (which had been noted by Ramsay also) are not due to variations in the emanation alone, and attributes them to its action on the gases mixed with it. The smallest volumes observed were 0.8 cubic centimeter at the beginning of the experiment and 0.58 cubic centimeter after the initial contraction. These values agree better with Rutherford's calculation than with Ramsay's experimental result. The mixture, even when richest in emanation, obeyed Boyle's law, proving that the emanation is a true gas.

The earth's loss of heat by radiation would be supplied by one fifty-trillionth of its weight of radium. The proportion of radium found near the surface is 20 times this, and as the thorium and other radioactive substances found near the surface would yield 20 times as much heat as the radium, a stratum 3 or 4 miles thick, having the radio-activity of the superficial layers, would furnish all the heat lost by radiation. As it seems unlikely that the radio-active matter is confined to so shallow a layer, it has been suggested that at greater depths radio-active transformation may be prevented, or even reversed (with absorption of heat) by the increased pressure. Henrich, however, could detect no radio-activity in a year's observation of lava from the last great eruption of Vesuvius.

All objects on the earth's surface acquire apparent radio-activity from contamination or contact with the omnipresent radio-active substances, and thus mistakes are made. Elster and Geitel have traced the radioactivity of lead to minute quantities of polonium.

Radio-active emanations abound in the soil and in most springs, but neighboring waters may differ greatly and the radio-activity of the same spring fluctuates incessantly. Certain medicinal springs are particularly active, and the Joachimsthal miners though frequently exposed to cold and wet, are said to be remarkably free from gout, rheumatism, and neuralgia. But, although radium emanation has proved beneficial in certain diseases, the therapeutic value of mineral springs cannot be attributed, in general, to radioactivity.

Nevertheless, the radio-activity of springs is important in many respects and should be determined in absolute measure. Statements of the fall of potential produced by a liter of the water have no scientific value, because they are not universally comparable. Engler and Sieveking have devised a very convenient portable instrument, the fontactoscope, which measures the saturation current produced by one liter of water. The unit of measurement, called Mache's unit, is 1/1000 of an absolute electrostatic unit.

By this method a great many Austrian waters have been tested for radio-activity. By far the highest value, 185 Mache's units, was shown by water from a pit in the uranium mines at Joachimsthal, where other pits gave values of 33 and 50. A radio-activity of 59 was found in water from uranium-bearing granite, 52 in a pond at Tannbach, and 51 in a mineral spring at Bad Froy. Other waters showed radio-activities ranging from 30 to a fraction of a unit.

The great radio-activity of the water at Joachimsthal suggested the project of establishing there a unique health resort. This created a condition of excitement, known as the "radium fever," in the adjoining kingdom of Saxony, which also produces uranium. It was suspected that the Bohemians had undermined the frontier and that some of the precious water was of Saxon origin. The Saxon government assumed control of all radio-active deposits and made an investigation, which proved that strongly radio-active water and uranium ores are not necessarily closely associated. The water of some well-ventilated shafts in the uranium mines showed very little activity, and, although strongly radio-active water was discovered at other points, the highest radio-activity found in a Saxon mine within five miles of Joachimsthal was only 9 units.—Condensed from Zeit. f. ang. Chemie.

OYSTER SHELL WINDOW PANES.

ON the west coast of India is found a species of oyster, *Placuna placenta*, the shell of which consists of a pair of roughly circular plates about 6 inches in diameter, thin and white. At present these oysters are collected for the pearls which they often contain, although few are fit for the use of the jeweler. But in the early days of English rule in India, says a writer in the Youth's Companion, the shells were employed for window panes. Cut into little squares, they produced a very pretty effect, admitting light like frosted glass. When the Bombay Cathedral was built, at the beginning of the eighteenth century, its windows were paned with these oyster shells. In Goa they are still thus employed.

It seems that the flower of the tea plant is much to be preferred to the leaf. The infusion of the flower is very sweet, and has the same stimulating qualities as the infusion of the leaves. Moreover, the flower contains only about two per cent caffein, while the leaf contains as much as four per cent. Tea leaves must be picked one by one; the flowers, on the contrary, are collected much more simply. The principal quality of the flower is the difficulty of imitating it. Imitations of leaves are innumerable. Most astonishing adulterations of tea leaves are practised in China. The oak, the eglantine, the ash, the strawberry, the laurel, the cherry, the chestnut, the olive, the elm, the apple, and the plum—in fact, almost every tree that grows—offers its leaves freely to unscrupulous dealers for mixture. Even ordinary wood sawdust, properly colored, has been employed. Fancy teas are adulterated with clay and other mineral substances. The tea flower is more or less proof against imitation.

FIELD GUNS FOR DESTROYING DIRIGIBLES.

RECENT GERMAN ARTILLERY AND SHELLS SPECIALLY DESIGNED FOR BRINGING DOWN MILITARY AIRSHIPS.

SOME interesting experiments have recently been carried out in the German army, with a view to determining the value of cannon as a means of defense against hostile dirigible balloons.

As we pointed out in a late issue of the SCIENTIFIC AMERICAN, the chief difficulties arise from the fact that the target not only changes its position very swiftly, but moves at will through three dimensions.

Not only must a rapid-fire battery be employed, but it must be arranged *en echelon*, so as to cover the greatest range, the roughly approximate distance, speed, and course of the balloon having been determined as quickly as possible by a suitable instrument.

The position of the tangent scale for the following shots must be fixed by an observer standing at one side, and the change of traverse and the height of explosion of the shell by the commander of the battery.

It is conceivable that thus attacked with shrapnel, a sufficient number of the thousands of balls and splinters directed against the balloon may pierce and damage it enough to cause its ultimate destruction.

This, however, must be accomplished while it is at a middle distance, for the nearer its approach the more difficult the conditions for the gunner, since not only is the lateral movement harder to follow, but the moment soon comes when the necessary elevation cannot be secured. If the tail of the gun balloon escaping from range by rising. This may be counted on with a maximum height of the balloon (according to Zeppelin) of 1,500 meters ((4,921 feet).

As regards the shot, it is desirable that shells should be used, and that they should have a time fuse; that they should evolve much smoke, and should also carry a slow-burning composition.

Shells are preferable to solid projectiles, not only because of the immense difficulty of hitting so rapidly-moving an object with a single shot, but because of the great distance at which the attack must commence; since the scouting airship will naturally approach no closer than is necessary for the accurate observation of details, which may be accomplished satisfactorily at a distance of 5,000 or 6,000 meters (3.11 or 3.73 miles) and a height of 1,000 meters (3,281 feet).

The time fuse must explode the shell by clockwork and not by fire at the distance determined upon by the commander of the battery, because the pressure of the air upon which the speed of burning of a slow fuse chiefly depends, varies so greatly in elevated strata of air that the commander must constantly change the height of explosion.

The copious emission of smoke at the bursting of the shell makes it possible to correct the aim.

A projectile carrying fire is to be desired because the instantaneous destruction of the balloon might be its locked position after the breech block has been closed. After the gun has been returned to battery and fired, it recoils again, thus compressing the air in the recoil and return cylinder.

The breech block is opened and closed automatically so the shell cannot slip back during the closure, and endanger the hand of the gunner.

Each gun mount is furnished with adjustable telescopic sights, which can be trained independently of the position of the gun, though it is contended by some authorities that an ordinary notched sight enables the gunner to get a better aim because he can follow the target directly and his field of vision is less restricted.

To attain a high elevation, the trunnions are fastened to the breech. The telescopic sights swing freely, so as to neutralize the slant of the gun.

In the guns of 7.5-centimeter and 10.5-centimeter bore the greatest traverse and the completest mobility in every direction are attained by placing the gun in a centrally-pivoted carriage, which allows it to swing through a complete circle of 360 deg. The same object is attained in the field carriage of the 6.5-centimeter gun by a device as simple as it is interesting. The wheels, by means of a swiveled spindle on the end of the axle, can be swung about 90 deg. toward the mouth of the gun and bolted in this

1.—6.5-Centimeter (2.5-Inch) 35-Caliber Krupp Balloon Gun in Field Carriage. Rear View with High Elevation. Cartridge to Left. 2.—The Same Gun. Gunner Taking Elevation for an Airship. 3.—Trajectory of a Smoke Shell Passing Above Target. 4.—7.5-Centimeter (3-Inch)35-Caliber Krupp Balloon Gun in Automobile Carriage.

carriage be sunk to restore this, on the other hand, the traverse is lost.

Experiments have shown, consequently, that ordinary field artillery is poorly fitted for defense against scouting or attacking airships. However, they have indicated pretty clearly the necessary conditions of improved construction, conditions which the Krupp firm has already attempted to meet, as pointed out briefly in the SCIENTIFIC AMERICAN of April 3rd.

These conditions may be summarized as follows: The guns must impart a very high velocity to the shot, so as to allow as brief an interval as possible for the target to change position. Furthermore, they must be capable of very rapid fire, so as to use favorable moments for the discharge of volleys.

The traversing mechanism, too, must enable the gun to move swiftly and easily in all directions, so as to follow the lateral movements of the target with precision. The importance of this condition is shown by the calculation made by General Lieut. Rohne and published in an article in the Artilleristischen Monatsheften for November, 1908, from which we quote:

"If the airship be moving past the battery at a distance of 4,000 meters (2½ miles) and with a speed of 15 meters (49.2 feet) per second (33.6 miles an hour), then the aiming gunner must in one second alter the traverse 15/4,000, i. e., about 4 points, or ¼ degree. If, for example, the traversing mechanism allows an alteration of only 7 degrees, which is quite sufficient for objects moving on the earth, then the airship would be out of range in 28 seconds, and the tail of the gun carriage would have to be moved sideways, which would delay the firing.

The gun must of course be given such power of elevation as to eliminate, if possible, the chance of the thus achieved, whereas the rain of balls and fragments from bursting shells would probably cause only its gradual sinking, without even certainty of capture.

These difficult requirements have been met in new ordnance recently constructed by the Krupp firm and by the Rhenish Metalware and Machinery Factory at Düsseldorf.

The Krupp firm makes a 6.5-centimeter (2.56-inch) 35-caliber cannon on a field carriage similar to that of an ordinary field gun, a 7.5-centimeter (2.95-inch) 35-caliber cannon for an automobile, and a 10.5-centimeter (4.13-inch) 35-calibre cannon to be mounted on a ship's deck.

The ballistic results of all three guns correspond to the given requirements with initial velocity of projectile of 620, 650, and 700 meters (2,034, 2,133, and 2,297 feet) respectively, these figures, however, being higher than those commonly attained with guns in practice.

Rapid fire is also achieved by the use of all the latest improvements.

The mechanical manipulation of the Krupp guns has been adequately described in the SCIENTIFIC AMERICAN of April 3rd. The 6.5-centimeter (2.56-inch) gun is equipped with hydraulic recoil cylinders and spring-actuated mechanism for returning the gun to firing position, as in most field pieces. The other two guns are simply equipped with automatic returning mechanism. A pneumatically-operated device for returning the gun to position, consisting of a compressed-air cylinder mounted on top of the jacketed gun barrel, pushes the gun forward, this effect being produced by the expansion of the air in the cylinder. The gun is automatically or manually released from position. They then revolve in a circle whose center is the swivel pivot at the spur in the tail of the gun carriage. The rough traverse is given by gripping the spokes, a finer traverse being obtained by swinging the revolvable upper portion of the carriage, which can be swung through an arc of 70 deg.

The gun on its field carriage can be elevated to 60 deg., thus enabling it to hold under fire an airship at any range from a maximum of 1,500 meters (4,921 feet) height and 7,500 meters (24,644 feet) distance, down to an approximate horizontal range of 900 meters (2,951 feet).

With an elevation of 75 deg. the automobile gun can cover a range of from 500 to 11,000 meters (1,640 to 36,089 feet). The naval gun has a range of 13,700 meters (44,947 feet). The greatest ranges are in general completely satisfactory. The minimum range can be considered so only in the case of the last two.

Two kinds of projectiles are provided for the three Krupp cannon, both containing a combustible. Both are effective only when the entire projectile penetrates the envelope of the balloon. Both contain a chamber holding a slow-burning composition for the purpose of evolving smoke, so as to indicate the trajectory of the projectile. This is necessary, because there is no cloud of smoke to betray the position, as there is at the moment of bursting of a shell.

The first, invented by Hartbaum of Essen, is both novel and ingenious. As shown in the diagram, it contains a chamber holding liquid oxygen. When the shell penetrates the hydrogen-filled envelope of the balloon, the pellet of platinum sponge contained at the end is brought to a glow, thus causing the detonation of the bursting charge, and thereby releasing the liquid oxygen. The mixture of hydrogen and oxygen

thus formed is exploded by the detonation, shattering the balloon.

The other projectile, designed by the firm itself, operates merely by igniting the gas in the balloon by means of the flames proceeding from the slow-burning mixture in the center and issuing through apertures at the top of the shot.

The first projectile is still untested, and is so new in principle that it is difficult to pass judgment on it. It remains to be proved that the desired effect would be accomplished in the brief interval of 6/100 of a second necessary for the shot to pass through the balloon. Moreover, it must be demonstrated that liquid oxygen can be stored and transported with the safety demanded by military conditions.

The other projectile has been tested experimentally. It was successful in sinking two 10-foot-diameter captive balloons swaying in a strong wind at a height of some 200 feet. It is not clear, however, whether this was due to the fire, or merely to the ripping of the envelope of the balloon. At all events, these experiments are not conclusive.

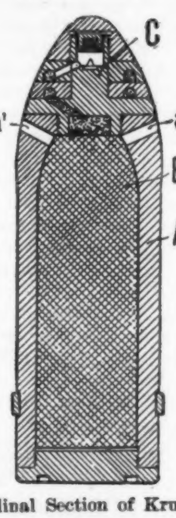
It seems probable that the best results are to be obtained from shells in which a loaded bottom chamber is exploded by means of clockwork, scattering a broad shower of shrapnel over the balloon from above, the shrapnel preferably having solid cores, so as to increase their ability to tear and penetrate.

The Rhenish Metalware and Machine Factory at Düsseldorf describes in its catalogue issued for the army and naval exhibition, an armored automobile with a centrally-pivoted 5-centimeter (1.97-inch), 30-calibre rapid-fire gun for the following and attacking of dirigibles.

The machine has a 50 to 60 horse-power gasoline motor, and is capable of taking a grade of 22 per cent even on bad roads; it develops a normal speed of 30 miles an hour.

The nickel-steel armor plate of the automobile is 3 millimeters (0.118 inch) thick. The openings can be closed and the forward part folded up. The armored dome connected with the gun is revolvable and provided with movable embrasure shutters. Behind the gun is the ammunition chest. Four spindle-shaped props can be let down from the inside to hold it firmly during firing. The gun, fastened at its center of gravity, can be changed in position with the greatest rapidity by means of a shoulder support, which is held by the aiming gunner in the position of a gun ready to fire. The recoil is overcome by a hydraulic shock absorber. It is manned by five soldiers. The ammunition chamber holds 100 shrapnel or cartridges. The aluminium double fuse cap has attached to its lower surface three curved toothed blades, which, owing to centrifugal force due to the rotary motion of the projectile in flight, swing outward and assist in tearing the balloon envelope.

The field of fire covers 60 deg. horizontally and 70 deg. vertically. The initial velocity of the shrapnel is 450 meters (1,476 feet), of the cartridge 572 meters (1,877 feet). The greatest range at 43 deg. of elevation is 7,800 meters (4.85 miles), the greatest range of explosion is 4,200 meters (2.61 miles).



Longitudinal Section of Krupp Shell.

A. Outer wall. B. Smoke-producing mixture. C. Time fuse. a'. Outlets for flame and smoke.

The ballistic qualities are satisfactory, and the gun may be considered as fitted for balloon attack, provided the ammunition can be made to conform to the conditions designated above by the addition of slow fire.

The brass rotating blades of the fuse cap may be considered somewhat artificial, since it is improbable that these would strike the balloon, and if they did so by chance, the entrance and exit would be sufficiently damaging without the tearing motion.

The Ehrhardt armored automobile gun was designed for following and attacking dirigible balloons, but for the purpose it is both too slow and too heavy. It is not very obvious what need this sort of gun has of armor. It is not likely to have to stand a siege, and its armor is merely so much dead weight to haul around (total, 7,054 pounds). The Krupp automobile gun, on the contrary, is intended merely for the besieging of a fortress or the defense of weighty strategic points. Its mounting is intended merely to facilitate a speedy change of base, the necessity of which may well be questioned. A single gun is inadequate for the delivery of that wide arc of fire needed to conquer such a foe. Or is it meant to unite these automobile guns in batteries?

But the conquest of airships does not offer such problems as compel the extra expense of specially-fitted batteries. It is preferable that each troop should have one battery so arranged as to be capable

5-Centimeter (1.96-Inch) Shrapnel Shell for Use Against Airships.

The cut away section shows the shrapnel and the smoke-producing compound at the bottom. The point of the shell (on the right) has curved toothed blades that are spread by centrifugal force to assist in tearing the balloon envelope.

on occasion of adding to its ordinary functions that of balloon defense.

The 10.5-centimeter (4.13-inch) ship gun fits perfectly into the scheme of naval defense against airships, aside from its ordinary uses. Correspondingly, the Krupp gun on the field carriage, which would seem the one best fitted to the needs of the army, might be made to agree in caliber with ordinary field artillery. United in batteries and provided for special occasions with balloon defense shot, it might, either in the ranks of its sister batteries, or in connection with independent bodies of cavalry, render invaluable service to the army by keeping off hostile balloons.

MACHINE TRACK LAYERS.

A VARIETY of machine track layers are being used by the railroads. These devices do not actually lay the track, but facilitate the delivery of ties and rails at the head of a construction train. The Harris system is one of the oldest. The ties are conveyed to the front by a train running on a narrow-gage track laid on top of the cars. A loading machine deposits a load of ties on the small cars, which are run forward by hand, and at the front are automatically dumped. The rails, carried on forward cars, are run to the front on dead rollers set between the rails of the narrow-gage track, and an attachment forward handles the rails.

The Hurley track laying device operates under its own steam, dispensing with a locomotive. The rails and ties are conveyed forward by power. The rails are carried on the rear cars. In running them forward, they are temporarily formed into two continuous lengths by means of angle bars. These extend from the front of the train to the rail supply, and are continually drawn forward by power compression rollers. At the front the rails are disconnected and put into the track. At the rear new rails are continually being added. Dead rollers are set up amidships on the intervening cars, and upon these the moving lengths are carried. The tie cars are situated ahead of those carrying the rail supply. The lowest ties are above the moving rail lengths, and by progressively removing the temporary support, the ties are dropped on the conveyor formed of the moving rails. When these arrive at the rear of the pioneer car, a special conveyor removes them from the rails and carries them overhead to a long cantilever projection extending ahead. From this they are finally dropped one by one on the subgrade. The rails are brought along beneath the cantilever. The whole train moves slowly but steadily forward, constantly discharging ties and rails.

In the Holman system rails are transported forward on one side of the train and ties on the other over lines of rollers. The rollers for the rails are grooved, while those carrying ties are cylindrical. The roller supports are in short lengths, flexibly connected, and set in brackets fitting into stake pockets of the ordinary flat car. At the front the final section of rollers is supported ahead by a cable or rod attached to a vertical frame. This support permits it to be shifted laterally, thus allowing delivery of the ties to be varied. The material is not conveyed by power, but the simplicity of the arrangement is advantageous; the chutes do not occupy loading space and are readily removed and replaced.—Iron Age.

ACTION OF WATER AND CARBON DIOXIDE ON CEMENT.

THE London Gas World publishes the results of J. Potter's experiments, extending over ten years, on the action of water and carbon dioxide on cement and cement mortar. The material was formed into blocks, having a cross section of one square inch, which were placed, twenty-four hours after molding, in one of the following:

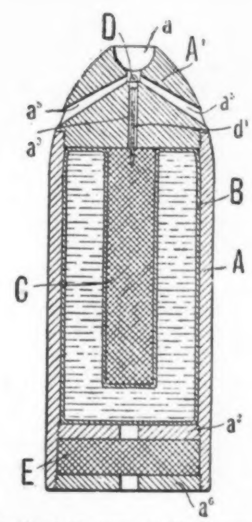
1. A reservoir of fresh water, changed every three months.
2. A reservoir of salt water, changed every month, and taken from the river Tyne at high tide.
3. A perforated box placed in the Tyne at the level of mean tide.
4. A vessel of salt water containing 10 per cent of magnesium sulphate.

Tests of the resistance to crushing stress gave the following results in pounds per square inch:

In Fresh Water.—Pure Portland cement, 435 after one week's immersion, with a regular increase during the ten years. Pure red cement, 228 after one week, increasing regularly to 541 after ten years. Portland cement mortar (3 to 1) showed for the first twelve weeks a slightly greater strength than red cement mortar (3 to 1). Afterward the two mortars became equal in strength, which was 500 in the tenth year.

In Salt Water.—Pure Portland cement, 400 after one week, 500 after twelve weeks, 0 in the fifth year. Pure red cement, 285 after one week, 640 after two years, with a gradual increase up to the sixth year, when the specimens were removed. Portland cement mortar (3 to 1) showed a slightly greater strength than red cement mortar during the first three weeks, but in the tenth year the Portland mortar tested 400 and the red mortar 584.

Action of Carbon Dioxide.—Having observed that 3 to 1 mortar exposed to carbon dioxide became very hard, Potter analyzed the mortar and found a large proportion of carbon dioxide, but no combined water. Blocks of mortar were then placed in a vessel of pure carbon dioxide. The blocks heated rapidly, lost water and absorbed carbon dioxide, producing a partial vacuum in the vessel. Carbon dioxide lightens the color of cement. It penetrates scarcely 1/25 inch into pure cement but very deeply into 3 to 1 and 5 to 1 mortar. Blocks of mortar (3 to 1) carbonated in this way during three years showed a crushing strength of 712 (Portland) and 755 (red). Nine days' carbonation and three years' immersion in a special brine gave 413 (Portland) and 698 (red); one year's carbonation and two years' immersion gave 912 (Portland) and 1,111 (red).



Longitudinal Section of Hartbaum Shell.

A. Outer wall. B. Liquid oxygen receptacle. C. Explosive charge. D. Pellet of spongy platinum. E. Smoke-producing mixture.

One year's exposure to an ordinary dry atmosphere followed by two years in the special brine gave 755 (Portland) and 841 (red), but one year in air dried by lime followed by two years' immersion reduced the strength of Portland mortar to zero and that of red mortar to 356 pounds per square inch.

The red cement employed in these experiments is a mixture of 10 parts of cement rock with 6 parts of calcined red-brick clay.

Fireproof Paper.—To make paper incombustible, moisten it with a solution of 8 parts of sulphate of ammonia, 3 parts of boracic acid, 2 parts of borax, and 100 parts of water. A solution of tungstate of sodium may be used for the same purpose.

THE PEARL BUTTON.

LIGHT ON A GREAT INDUSTRY.

EXTENT OF THE BUTTON INDUSTRY IN THE UNITED STATES.

IN 1905 the value of buttons manufactured in the United States, as given in a special report of the Census Bureau, was $10,074,872. This was an increase of $3,564,709, or 64.6 per cent, over the value of the product in 1900. Of the total button product, pearl buttons constituted nearly one-half (48.3 per cent), or $4,870,274 in value. Over two-thirds of the pearl buttons were made from fresh-water shells and somewhat less than one-third from ocean shells.

The number of button factories in the United States in 1905 was 275. These represented a capital of $7,783,900, and gave employment to 11,335 persons, to whom were paid in salaries and wages $4,691,669. The aggregate value of buttons and by-products from these factories during 1905 was $11,133,769. Over half of the 275 button factories in the United States engaged to a greater or less extent in the manufacture of pearl buttons, an increase of over 20 per cent since 1900 in the number so engaged. New York, with 27 factories, produced pearl buttons in 1905 to the value of $1,844,432; Iowa came next, with 51 factories and products valued at $1,500,945; New Jersey, as the third in production, had 11 factories and turned out $480,765 worth of pearl buttons.

VALUE OF BUTTON IMPORTS.

The imports of buttons and button forms of all kinds were valued in 1905 at $866,178, in 1907 at $936,085, and in 1908 at $652,691. These came principally from France, Germany, and Austria-Hungary, the relative amount from each of these countries ranking in the order named. Under the head of pearl and shell buttons the Bureau of Statistics gives imports to the value of $172,101 for 1905, $164,154 for 1907, and $92,629 for 1908. It would appear that the United States is very nearly meeting by domestic manufacture its constantly increasing demand for pearl buttons for home use.

Imports of buttons from Japan, mainly pearl, although only $2,004 in value in 1907, have nevertheless nearly trebled over those of 1905. In view, therefore, of the considerable increase in recent years in the manufacture of pearl buttons for export in Japan, and the introduction of machinery into the button factories there, an examination of the methods followed will be of interest to American manufacturers. The following facts are gleaned from a German consular report on the subject:

MANUFACTURE OF PEARL BUTTONS IN JAPAN.

Japanese pearl buttons come into the market under the names of the shells from which they are made. The principal kinds are: Takase, shinju, awabi, sazae, and hirose. The first mentioned of these are found on the Ryukyu Islands; also about Formosa, the South Sea, and the Dutch East Indies. The best shinju are obtained from Ise and Omura. Formerly many were imported from India, the shells from which are thicker and permit shaping of the buttons by boring out. Since the question of prices has, however, become a more important point, the thinner and cheaper Japanese shinjus are used almost exclusively. Awabi shells come from the islands near the west coast of Kyushu, particularly from Gotshima and about Hirati. Sazae shells are obtained for the greater part from Iyo and Bungo. Fishing for hirose shells has been decreasing at the Ryukyu Islands for some time, as the beds near at hand have become exhausted, and it has not been found profitable to work at greater distances.

COST OF SHELLS—NUMBER OF FACTORIES.

The prices of shells vary greatly, according to the quality of the lots. Takase shells may be bought as low as 5 yen (1 yen = 49.8 cents) per 100 kin (1 kin = 1.34 pounds), or $1.86 per 100 pounds, but there are also grades costing as high as 20 yen per 100 kin, the average price of shells most used in Japan in making buttons for export being about 10 yen. Some 60 gross are made from 100 kin. Hirose shells are now about the same in price as takase. Awabi cost more, the dearest bringing as much as 45 yen per 100 kin. These shells are globular in form, and are used in the making of large buttons, while for small buttons the so-called "ears" of the shells are utilized, these costing only about 1.50 yen per 100 kin, the buttons from them being largely exported as blanks. Shinju shells bring about 4.50 yen. Sizae are cheap, that is, about 2 yen per 100 kin, but the available part is very small. While 100 kin of shinju shells give approximately 250 gross of number 16 buttons, the product of an equal weight of sazae shells is usually only about 50 gross.

Sailing vessels bring the greater part of the shells to Kobe or Osaka, the latter being the chief market, although large lots are often obtainable in Tokyo.

There are five of the larger button factories in Kobe and Osaka, and some 80 smaller shops in Osaka and the Kavansai district. In the latter a single family often does all of the work. There are also many such small shops in Kyshu, and some in Kioto, Okayama, and Kyushue. The largest factory is in Kobe, which, under favorable conditions, gives employment to 150 persons. All of the work from the shell to the bleaching is done here, the sewing of the button on cards being the only part performed by working people in their own houses. Each workman in the factory is assigned to a special line of work, and is paid according to the number and quality of the buttons turned out. The tools which he uses are generally his own property.

BUTTON-MAKING FOLLOWED IN HOMES—METHODS.

In Osaka the work is done for the greater part by the piece in separate factories or in houses, although factory work and house manufacture go hand in hand. Boring of the blanks and shaping is done partly in the factories and partly outside. In many houses a specialty is made of boring the holes. Bleaching is done by the factories themselves, while the sewing of the buttons on cards is done by many outside workers, silver, paper, cardboard, and thread being furnished to the latter. These smaller workmen rarely buy shells to work up, but are paid by the gross to do certain parts of the work on shells or buttons issued to them.

The buttons made from takase shells are the most important of those produced in Japan. The manner of their manufacture is as follows: First, the blanks are blocked out. The boring machines for this purpose are all alike in principle. The new ones, however, have a balance wheel, with a cogwheel for the transmission of power, and are worked by a treadle, while the old ones are turned by hand. The boring tool itself is of steel and in the form of a hollow cylinder. This is pressed by means of a spiral spring against the shell, thus boring out plates of a size corresponding to the diameter of the cylinder. The under surface of the shell is first worked upon, then the lowest side ring. The adhering outside skeleton is then broken off by the children, and the adjoining under surface and the next ring are worked up, and so on until near the tip, where the shell becomes white and salty and not utilizable for buttons. No use has thus far been found for the outer skeleton. The blanks or plates are sorted out according to their thickness, and any projecting portions which remain on the under side are broken off.

POLISHING AND BORING THE BLANKS.

The polishing of the blanks on both sides is the next step. To accomplish this, they are laid on an iron disk which has a large number of round depressions exactly the size of the blanks. Moist clay is then put over them and the rough surfaces are polished by rubbing with heavy flat stones. Shaping up is then begun. The blanks are fastened singly in a wooden spindle attached to a turning lathe, the end of the spindle being split and having a suitable cut for holding the blank, and the latter being clamped by a sliding ring on the spindle. The workman turns the spindle by means of a treadle, and at the same time shapes the surface of the button blank with various implements.

The blanks are then put into what is known as a "drum." This is merely a large receptacle which is suspended and is constantly turned by boys. Water and clay having been added, the continued rubbing together of the button blanks in this substance wears away any rough surface left by the tools.

Boring the holes is the next operation. This is also done on a lathe, either with one needle or with two or four needles. Arrangements for boring several holes at the same time are rarely found outside of certain workshops in Osaka, where nothing but boring is done. The boring apparatus in use is still rather impractical, the setting of it for the various sizes of buttons and sizes of holes being troublesome. In small shops and in factories, where all of the operations from start to finish are performed, most of the boring is done with one needle only, which is usually a pointed bit of steel taken from an umbrella frame. Against this needle in rapid revolution the button blank to be bored is pressed, the latter being firmly clamped in a small handle constructed in a manner similar to that in which the button blanks are held when the surface is shaped up. This handle is square and lies in a right-angled trough, in which it is turned twice, or four times, according to the number of holes desired in the button. The needle is so placed that it strikes the button at one side of the center. Considerable skill is required, however, and boring with several needles at the same time is considered safer in general.

MANNER OF BLEACHING.

The next process is that of bleaching. This is accomplished by letting the buttons remain for a time in earthenware pots placed over glowing coals and filled with water in which an acid has been mixed. The time required for proper bleaching varies with the thickness of the buttons, being usually 3 to 5 days, but very thick or large buttons may even require longer. The principal acid used is sulphuric, which is easily obtainable in Japan. Each manufacturer is apt to believe that his special process in bleaching is superior to that of others, and he therefore endeavors to preserve it as a secret. It is believed, however, that all are fundamentally the same.

It is important not to leave the buttons to bleach too long, as they then lose their luster and become brittle—faults which cannot later be remedied. The bleached buttons are placed in cotton sacks, which are then vigorously pulled and drawn back and forth by two men, one at either end. In this way the buttons are made to rub against each other and against the sides of the sack and become polished. Large buttons are usually put into the lathe again and polished one by one with a cloth and polishing powder. The buttons are then sorted according to quality and sewed on silver paper, with cardboard underneath, and placed in wooden boxes. The smaller and cheaper buttons are often sewed on blue paper without cardboard. These are usually put up in lots of a gross each, while the larger ones are put up in cards of two or three dozen.

WORKMEN EMPLOYED AND SCALE OF WAGES.

The shaping up of the blanks is mostly done by men; likewise much of the cutting out of these blanks from the shells, while the rest of the work is almost exclusively done by women. As the takase shells are expensive only skillful workmen are employed in shaping them up. Hirose and awabi shells are worked up in the same manner as takase, only the awabi are not bleached. Sazae are treated much in the same way, except that in this case the shells are first broken into convenient pieces and these are then worked up one by one. This is nearly all done by half-grown girls. Sazae and also shinju buttons have to be sold cheaply, hence the wages for work on them are low and the workmen give up this line as soon as anything better can be had. The making of buttons from shinju shells is simpler. After the blanks have been cut they are placed in the drum to be polished, then they go to the lathe where a circle is traced parallel to the circumference, the holes are bored, and the buttons are then put into the hot acid water for a short time to give them a luster. They are then sewed on thin silver paper or on blue paper.

The following prices are paid per 1,000 for work on shinju buttons: Boring the plates, 4.5 sen (1 sen = ½ cent); carving circles, 2 sen; boring two holes, 8 sen; per 12 gross, for cleaning in the drum, 2 sen; and for sewing on paper 5 sen. For sazae buttons somewhat more is paid, the material being somewhat thicker, harder, and heavier to work. Boring out the blanks from the shell costs 13 sen, shaping surface 26 sen, and boring holes 12 sen per 12 gross. These prices are for size No. 16. Notwithstanding the cheapness of this work buyers have in recent years become very critical as to any irregularities. These are liable to occur as the workmen change frequently and in fact only take up with this work, as a rule, for the purpose of learning how to make more valuable buttons. Formerly both the making of blank buttons and the boring of holes were done in prisons. This is continued only in Okayama. Payment is made in this case by weight.

INTRODUCTION OF MACHINERY INTO FACTORIES.

Up to a very recent date hand manufacture was followed exclusively. Not long since, however, a maker in Osaka installed a gas motor with which he drives a large polishing wheel for finishing both surfaces of the buttons. The Kobe factory plans the introduction of motive power, but up to the close of 1908 had not secured proper electric connection. Whether the arrangement will pay or not remains to be seen. The Osaka factory has had good results with the polishing apparatus installed, and many of the other manufacturers send their blanks there to be further worked up.

Fire lighters may be made as follows: 300 parts of rosin and 15 parts of crude paraffine are melted with 15 parts of a fat oil and to the molten mass 100 parts of cork dust and 75 parts sawdust are added. When cool, the mass is molded into briquettes or narrow strips.

ELECTRICITY IN THE MINE.

A NEW PROCESS OF MAGNETIC ORE SEPARATION.

BY C. H. CLARK.

THE magnetic properties of certain ores early suggested the possibility of utilizing electro-magnetic principles in the concentration of these ores. This idea was first conceived at a time when electric current was not very generally available commercially, a fact which prevented the development of such apparatus at that time. However, with the present-day facilities for obtaining electric current in any locality, this system has been made commercially possible. The efficiency and economy of this system in the concentration of magnetic ores have established magnetic ore separators in the favor of all mining engineers who have had experience with their operation.

The separator here shown is of the bipolar, revolving-drum type, the field magnets being energized by means of two form-wound field coils of large capacity. These coils are amply protected to withstand the most severe service, and are mounted on the two legs of the field magnet. The field frame is cast from the highest grade dynamo steel, and the revolving drum or armature is built up of steel laminations. These laminations are carefully annealed, thus reducing to a minimum the core loss in the armature, and consequently the power required to drive the armature.

There is no winding or electrical connection of any sort on the armature, a construction that insures reliability under the most severe conditions. The only moving part in the operation of the separator is the armature, which is rotated by means of a pulley, belted to a shaft or electric motor. The motor drive is preferable because the speed can be adjusted to suit the conditions of operation. The material to be separated is fed from the hopper, at the top of the machine, through an adjustable gate, the function of which is to regulate and distribute the feed onto the armature. By the revolution of the armature the material is carried under the pole face at one side. Because of the magnetism induced in the armature at this point, the magnetic material adheres to the armature, while the non-magnetic material drops off. On each side of the armature is a field pole, for directing and concentrating the magnetic field of force. There is, therefore, at or near the bottom of the armature, a neutral point or a point where a reversal of magnetism takes place. As this point of reversal is approached, the magnetic attraction of the armature gradually becomes weaker, while at the neutral point there is no magnetic attraction whatever, so that even the most highly magnetic material is thrown off at this point.

By means of the adjustable deflector plates arranged beneath the armature, as shown in the sectional drawing, the different products may be collected as desired from the under-surface of the rotor, as they are successively thrown off under the gradually weakening attraction. By this means several different minerals may be separated in one operation, and so fine is the adjustment obtainable that minerals differing but very slightly in magnetic susceptibility may be separated with the greatest facility.

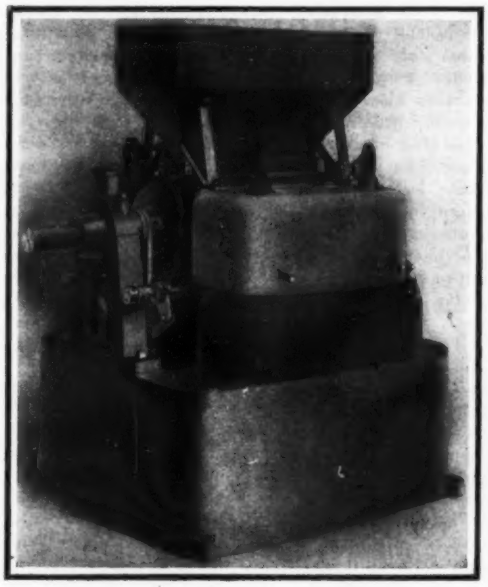
Any tendency that non-magnetic materials might have to adhere to the armature is overcome by the centrifugal force of the revolving armature itself. By adjusting the speed of rotation this force may be given any value desired, and it can be balanced with the attractiveness of any one of a series of magnetic materials it is desired to separate; a feature which furnishes more positive separating force than can be obtained from the mere weight of the particles as utilized in gravitation methods of ore concentration.

Separators of this type have a much larger capacity than any other yet developed, separating from sixty to one hundred tons per day, and in some cases even more.

In addition to ore separation, these machines are especially well adapted to the separation of "flue dust" from blast furnaces, maintaining as they do a uniform product, a feature of the greatest importance in this work. Other successful applications of this separator are cleaning up bone ash, glass sands, etc., as iron in any form is removed with facility; even materials which are merely covered with a coating of iron oxide being readily separated. By means of rheostatic control of the field current, these separators can be made to operate with equal efficiency on materials of the lowest magnetic susceptibility as well as the highly magnetic materials, such as metallic iron. Separations can be made on a commercial basis of iron carbonates from zinc blende; manganese ore from quartz; magnetite from beach sand; magnetite from talcy gangue, pyrites, and chalcopyrites; different minerals found in black sands of placer concentrations; wolframite from associated minerals; iron and iron-bearing minerals from crushed quartz; hematite from jasper and quartz; chalcopyrite and pyrites; pyrrhotite and chalcopyrite; pyrrhotite and pyrites; rhodonite, garnet, zinc blende, and lead sulphide; flue dust (blast furnace product) from coke, etc.; roasted zinc ore extracting iron from zinc, lead, silica, etc.; iron and iron minerals from bone ash; iron and iron-bearing minerals from glass sands.

The flexibility of the electrical system of power transmission makes this system especially desirable in mine operation. With this system, power or lighting apparatus can be obtained at any point desired on a moment's notice; the only thing necessary to transmit the power from the power plant to the machine being the wires, which may be readily extended or moved with the greatest facility.

Because of the convenience of control of electric motors, the efficiency of mining machines, hoisting apparatus, crushers, drills, etc., is greatly increased by the application of electric motors. By means of motor-driven fans or blowers, any part of the mine may be supplied with good ventilation, eliminating the dangers of explosion and protecting the workmen from poisonous gases. A good system of ventilation also keeps the atmosphere dry, a condition that is not only desirable for the workmen, but also increases the life of the machinery and timbers of the mine.



A NEW MAGNETIC ORE SEPARATOR.

The illumination of the mine with the old system has always been very unsatisfactory, and a great source of danger from fires and explosion. However, with electric lighting apparatus absolute safety is insured, and the most remote portions of the mine can be kept well illuminated at a comparatively low cost. In fact, every department in the mine and smelting plant suggests a means by which the efficiency and convenience of the various operations are augmented by the use of electrical apparatus.

In the majority of cases the alternating current equipment is best suited for mine operation. If the mines are scattered over a large territory, the power may be transmitted at higher voltages than is possible with a direct-current system. In this way the efficiency of transmission is increased, and the first cost of the transmission lines reduced.

The simplicity of the squirrel-cage induction motor makes it especially suitable for severe service such as is met with in mines. There are no sliding contacts, hence no sparking whatever, and no electrical connection of any sort on the rotating part.

Where high starting torque and low-current consumption are desired, the slip-ring type of motor is used. This motor contains a winding on the rotor with which connection is made to a starting resistance, by means of slip-rings. However, as the rings are continuous and present a perfectly smooth surface to the brushes, dust and dirt do not have any injurious effect on their operation.

Where the power need not be transmitted over great distance a direct-current system is found suitable, the series direct-current motor being especially well adapted for the operation of hoists, cars, etc., where large starting torque is required. In places where the motors are exposed to the weather or excessive quantities of dust, they are furnished completely incased, and are thereby made proof against any injurious effects from these sources.

ANOTHER ELECTRICAL TRIUMPH IN THE MUSICAL WORLD.

A NEW musical instrument operated by electricity has lately made its first public appearance in Boston at a concert, in which the Boston Symphony Orchestra also took part. The new device is called the choralcelo, and its essential peculiarity consists of the vibration of piano wires by electromagnets, resulting in the production of tones of surpassing purity, if the judgment of those who have heard the instrument is to be credited. The working parts of the instrument are housed in a case resembling that of a rather large upright piano, and the instrument may be played as a piano by the ordinary percussion hammers and keys, either separately or at the same time, with the electromagnetic action. The tones of the instrument are said to resemble those of both stringed and wood equipment for orchestral service, and the organ characteristics are reported to be perhaps the most beautiful of all. Less than one horse-power of electrical energy is required to operate the choralcelo in full harmony.

The future of such an instrument must be left to the musical world, but from the scientific point of view it is significant that electricity should be the medium for the production of effects which never before have been heard by the human ear. The choralcelo principle being established, electricity has added one more benefaction to human enjoyment. Mankind will find it hard to pay the debt it now owes to this wonderful medium, which astonishes us year after year with its achievements in the betterment of conditions on this troubled planet. Life without electricity is now almost unthinkable in civilized communities. Each new step forward, whether in the transmission of the energy of mighty cataracts over vast and varied reaches of land and water to drive the looms of industry hundreds of miles from the power house, or in the improvement of human intercommunication or enjoyment, marks the approach of the goal at which civilization will depend upon electricity almost to the exclusion of all other natural agencies. The possibilities of the immaterial bridge of ether between the cause and its effect desired, are yet far from exhausted. We often hear it said that the electrical field is overcrowded with workers, but the introduction of new apparatus for the benefit of humanity constantly expands it. We may discover few fundamental principles in the early part of this century, but each new application which does something better than before, or which creates an entirely new source of profit or enjoyment, widens the sphere of the whole electrical world. The indirect benefits of each new development are difficult to measure, but they are real. The introduction of a new device and the creation of a demand for it stimulate activity all along the line. Existing facilities are used to a larger extent, labor is freshly employed and materials purchased and transported. Demands for power, light, and communication arise, to the benefit of the central station and the manufacturing plant. It is desirable to realize these incidental conditions no less than the fundamental gain which the world obtains when a new development is perfected.—Electrical Review and Western Electrician.

Perfumed Paraffine Tablets.—Melt paraffine in the water bath and add, according to desire, a quantity of essence (essential oil), mix thoroughly and pour into molds; with the tablets, handkerchiefs and articles of clothing can be rubbed. I. 125 parts of paraffine, 7 parts of essence of lavender, 3 parts essence of cloves, 1 part essence of geranium, 7 parts of essence of bergamot, ½ part of vanilline, 3 parts of glycerine. II. 250 parts of paraffine, 3 parts neroli essence, 3 parts essence of bergamot, 3 parts essence of geranium, 7 parts essence of lavender, ¼ part essence of cloves, 1 part heliotropine, 3 parts glycerine. III. 125 parts of paraffine, 7 parts essence of ylang-ylang, 1 part coumarin, 1 part essence of musk, 3 parts essence of cloves, 2 parts essence of sandalwood, 3 parts glycerine.

ENGINEERING NOTES.

As far back as December 15th, 1799, Thomas Grenville wrote from Stowe to Lord Grenville: "I have this moment received an explanation of the electric lamp which I enclose for the evening amusement of all at Dropmore. Its cost—including packing—is just under five louis d'or." Whose experimental lamp can this be? One of Volta's perhaps?

An Italian officer, M. Pirandello, has installed a small station on the sea coast near Rimini in which he uses wave power for producing current by an apparatus invented by him. The apparatus is intended as a first step toward a more extensive use of the system. He applies the current not only for lighting but for the decomposition of water so as to obtain hydrogen and oxygen. The gases are then compressed in the usual way in steel tubes.

A paper read by Mr. C. H. Procter before the American Brass Founders' Association contains a description of electro-chemical methods of cleaning articles previous to electro-deposition of metals. The cleaning bath should be of wrought iron and heated by iron steam coils, and the author recommends for an electro-cleaning solution for ordinary purposes 3 ounces to 4 ounces of caustic potash to each gallon of water, and to every 100 gallons of solution 8 ounces of cyanide of potassium. When the articles contain much oil or grease on the surface, the density of the solution can be increased.—The Engineer.

The Italian government is taking measures to use electric traction on several sections of the State railroad lines in the near future. One of these is the mountain road from Genoa to Bussala. Three-phase locomotives of 1,800 horse-power are to be used, with 120-ton trains made up of 21 double cars. Current is furnished from a steam turbine plant at Genoa which is now building, but later on hydraulic power may be used. The locomotives are of the Westinghouse type and are supplied at 3,000 volts from an overhead wire as in the Simplon tunnel. Each locomotive has two 900-horse-power motors.

In an article in the Engineer, London, Mr. F. V. Vernon states that a good rule for the horse-power required to drive machine tools is to assume one horse-power for each 10,000 square inches of belt delivered to the machine per minute. This rule is based on a working belt pull of 39.6 pounds per inch of width tending to rotate the pulley, a rule which, it is stated, is justified by the author's experience, and which may be demonstrated as follows: 10,000 square inches of belt per minute = 10,000 linear inches of belt one inch wide per minute = 10,000 ÷ 12 linear feet of belt one inch wide per minute. As each inch of width of belt is assumed to carry 39.6 pounds of effective tension, the power transmitted will be:

$$\frac{10{,}000}{12} \times 39.6 \text{ foot-pounds} = 33{,}000 \text{ foot-pounds},$$

$$\text{or H. P.} = \frac{\pi DWn}{10{,}000}$$

in which formula, D = diameter of pulley in inches,
W = width of belt in inches and
n = revolutions of pulley per minute.

A tight double belt may transmit twice the amount of power given by the above rule; but although the machine must be strong enough to resist the extra pull, yet it is not wise to provide for double the motive power where a separate motor is used, as most motors will stand as much temporary overload as a belt, and no belt will work well with a permanent overload.

SCIENCE NOTES.

According to the Journal Soc. Chem., it has been shown that small quantities of bismuth exert little or no influence on the chemical relation of copper and nitric acid.

A correspondent of Nature points out that it is a matter of common knowledge that the time for which the breath can be held is increased by a preliminary bout of deep breathing. Divers have made use of this fact to increase the time for which they can remain under the water. It is not usual to perform this forcible respiration for more than a short period. The pearl divers of Ceylon, for instance, take only a few deep breaths before descending. In order to get the maximum effect, a prolonged period is necessary. Nature's correspondent states that in his own case, while with no preliminary forced breathing he could hold his breath for only 42 seconds, he could hold it for 2 minutes and 21 seconds after one minute's forced breathing; for 3 minutes and 21 seconds after three minutes' breathing; and for 4 minutes and 5 seconds after six minutes' breathing. Apparently the effect of forced breathing is to wash out considerable quantities of carbon dioxide from the blood and body tissues. Contrary to the supposition that the deeper and more rapid the forced breathing the greater should be its efficacy, it seems that the muscles of the hands after prolonged breathing pass into a condition of chronic rigidity, and remain completely paralyzed for the first minute or so of breath holding. It seems that forced breathing should, therefore, not be continued for more than two or three minutes.

M. Paul Becquerel made experiments on grains which tend to prove that their life is not only in a latent state but in some cases can be completely suspended, without losing their power of germination. He takes wheat and mustard grains and dries them by a special process for six months, then seals them in tubes after producing a high vacuum. The tubes were taken from Paris to the laboratory of M. Kamerlingh Onnes at the Leyden University where they were placed in liquid air and then at —253 deg. C. in a liquid hydrogen apparatus for 77 hours. After the experiment it was found that the grains would grow quite as usual. We can hardly admit that the grains having their tegument perforated and then totally dried, then placed for one year in a high vacuum and finally cooled in liquid air for 3 weeks and for 77 hours at —253 deg., can have lived even in a latent state, and he supposes that the vital functions were completely stopped. The protoplasm, kept without water and at an air pressure almost zero also at a temperature near absolute zero, becomes as rigid, hard and inert as a stone. Its colloid state, which is necessary for manifesting the physico-chemical functions of assimilation and the reverse, thus totally disappears. We seem to demonstrate the complete stopping of life in this case, and this is against the admitted law that life is a succession of continuous phenomena which cannot have the least stop without resulting in death. Transmitted from one generation to another, it has never been discontinuous. It now seems that such an interruption is not only possible, but real; and it may be continued for a time which seems to be indefinite, as we have no idea at present of the limits to which this apparent stopping of life can be carried out. The question as to whether the vital functions of the grain are entirely suspended, as the author claims them to be, is of course open to discussion.

TRADE NOTES AND FORMULÆ.

Gratteau's Fire Lighters.—Wooden sticks, of suitable length, are dipped in petroleum, turpentine, etc., and tied together in bundles. Dry wood is disposed about these and it is coated with rosin to prevent the evaporation of the volatile constituents.

Parquet Floors.—To remove grease spots from parquet floors rub the spot with soft soap thoroughly, pour some strong alcohol on to it and light it, taking the proper precautions. Do not allow the clothing to come too close to the flames. After the flames are extinguished, scour several times thoroughly with very hot water; the spot will then certainly have disappeared.

Stamp Pads.—35 parts of Japanese gelatine Tjen Tjau are boiled with 3,000 parts of water to effect solution, poured boiling hot through flannel, mixed with 600 parts of glycerine and evaporated to 1,000 parts. To 100 parts of this mass, add 6 parts of methyl violet 3 B or 8 parts of eosine B B N or 8 parts of phenol blue, 3 F, or 5 parts of aniline green D or 10 parts of nigrosine. To make the desired pads, it should be run into shallow tin boxes, covered with muslin and, in case the surface dries out very much, moistened with water or glycerine.

Solid Spirits.—According to an English patent, collodion is poured into spirits, or nitrocellulose is dissolved in a mixture of spirits and ether; slow evaporation of the mixture produces a jelly-like mass. The spirits can also be in part replaced by a cheaper hydrocarbon, such as benzole, benzine, etc. For illuminating purposes, candles with a wick are formed from the substance, with addition of a little soap, which are wrapped in paraffin paper or tinfoil. For heating purposes, a little soap is added to the jelly-like mass, which may also be perfumed and blocks formed with the aid of sawdust, wood charcoal powder, powdered rosin, or cellulose.

Paramentine is the name given by Torlotin to a finishing preparation invented by him and consisting of 100 parts of gelatine glue, dissolved in the smallest possible quantity of water, with an addition of 70 parts of dextrine and 20 parts each of glycerine, Epsom salts, and white vitriol. The whole to be well mixed and dried in molds. According to a new formula by Treppel, paramentine may also be made up as follows: 100 parts of glycerine, of 20 deg. Bé., 1 part carbonate of soda and 1/100 part each of alum and borax are dissolved, and to this 10 parts of wheaten or potato starch are added. To this mixture may also be added, as desired, gelatine, fat soaps, stearine, gum arabic, or gum tragacanth.

Food Vinegar from Pyrolignite of Lime.—For the decomposition of pyrolignite of lime, hydrochloric acid is used; as a rule, 89 to 90 parts of hydrochloric acid suffice for 100 parts of dry pyrolignite or acetate of lime. By a simple test, the right quantities can easily be determined. The acetic acid, brought over by distillation, when treated with a solution of nitrate of silver, should show only slight opalescence; if a heavy precipitate is formed, this indicates an excess of hydrochloric acid. The distillation is effected in an ordinary distilling apparatus, the copper head of which must be tinned inside. The cooling worm is best made entirely of tin. The temperature should never run higher than 263 deg. F. The crude acid obtained is purified by rectification or redistillation. Rectification is effected in a distilling retort in which 0.5 per cent of the weight of acetic acid used, in acetate of soda, has been placed. If the acetic acid only smells very faintly of smoke, it can be freed from this odor by filtration through cooled wood charcoal; if it contains more, it must be rectified with 1 per cent of bichromate of potassium, and almost pure acetic acid will be obtained. By avoiding an excess of water we obtain almost one-half pure acetic acid, and with water the product yields vinegar of the best quality.

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